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THE SIX-INCH MACADAM STREETS OF HUDSON, N. Y.

By H. K. Bishop, C. E.*

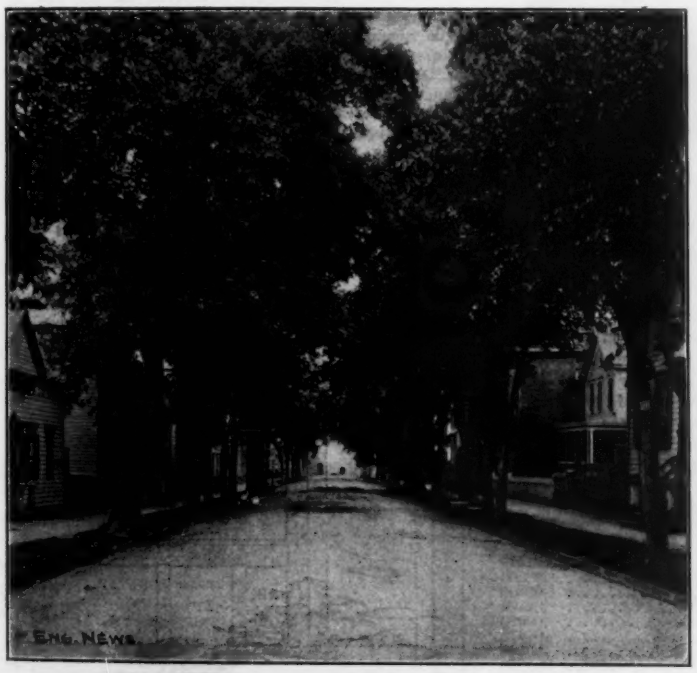
Few cities have made a more marked improvement in their streets than has Hudson, N. Y., during the past eight or ten years. Here will be found a striking example for advocates of good roads. The change has been gradual but steady; from a city noted for its uneven, and, at times, almost impassable streets, to a smooth macadam pavement unaffected by the condition of the weather. The money expended to bring about this changed condition has undoubtedly been returned to the taxpayers in the saving of wear and tear on horses and vehicles; also decreasing the cost of transportation and a saving in repairs; to say nothing of the pleasure and safety afforded thereby to the public.

Prior to 1893, Hudson expended thousands of dollars annually in an attempt to better the condition of its side and back streets. Such attempts, however, were carried on without scientific advice and experience, and were characterized by political influence. Large quantities of so-called gravel were drawn into the streets in the spring time and hauled away as mud in the fall. Honest attempts were undoubtedly made to gain better streets, but these attempts lacked an accurate knowledge of the principles of good road construction.

In 1895, a new city charter went into effect, creating a commission of public works, consisting of three taxpayers, appointed by the mayor, and placing at their disposal $100,000 for the purpose of putting the streets of the city in a better condition. A portion of this money had already been expended in paving Warren St. with asphalt blocks. There remained about eight to ten miles of residence streets to improve with the balance of about $60,000. Macadam was therefore selected as being the cheapest and best suited to the streets of the city. In selecting macadam the commission was also governed by the fact that the underground systems of water, gas and sewer pipes were very old and in constant need of repairs, and the streets would necessarily have to be frequently torn up. About this time the city became the owner, through the purchase of lands for a new cemetery, of a stone quarry about 1½ miles distant from the central portion of the city. This quarry had a good face and had been formerly worked in connection with a lime kiln. By an expenditure of about $3,000 the commission bought and set up a No. 2 Climax crusher and screen, a suitable engine and a pair of scales. The stone from this quarry was a limestone having, according to a test by the U. S. Good Roads Department, a specific gravity of 2.71, a weight of 169.69 lbs. per cu. ft., and absorbing 0.51 lbs. of water per cu. ft. The Department coefficient of wear is 72.05; the French coefficient of wear is 7.57; per cent. of wear, 5.59; cementing value, 95; re-cementing value, 29. This rock has given good results upon light traffic streets, but wears too rapidly for the streets of the heaviest traffic. It is, however, the best local stone obtainable.

The next step was to employ an engineer for superintendent of public works, who proceeded to grade and prepare plans for macadamizing a number of streets. Contracts were let to local contractors to pave these streets with 6 ins. of finished macadam for 46 cts. per sq. yd. A large portion of the city was macadamized under this and subsequent contracts, varying in price from 43 to 46 cts. per cq. yd., the city furnishing the use of the stone crusher and quarry

*Superintendent of Public Works, Hudson, N. Y.



View on Lower Part of State St.—30 ft. Between Curbs.

View of Willard Place—25 ft. Between Curbs.

NARROW PAVED RESIDENCE STREETS IN HUDSON, N. Y.

free, and the contractor furnishing his own roller.

In 1900, under the direction of the writer, the city began to lay its own macadam by day work, letting out by contract the crushing and drawing of the stone. In this way streets were macadamized at about the same cost to the city with much more satisfactory results. This method has been followed to date. A brief description of the cost, and the method of doing this work may be of interest.

QUARRYING AND CRUSHING.—The contract price of quarrying, crushing and screening the stone has been 43 cts. per ton. The drilling has been done with steam drills, and the blasting with dynamite. The stone was loosened and loaded by hand into carts and hauled about 150 ft. to the crusher, where two men were kept constantly feeding. After the stone was crushed it was elevated to a screen and screened into three different sizes. The sizes of the holes of the screens were ¾-in. and 2 ins. The stone was drawn direct from the bin to the street when it was possible; at other times it was deposited in piles at one side of the crusher.

The actual cost to the contractor for quarrying and crushing the stone was as follows:

	Per ton.
Drilling and blasting	$0.0425
Loading	.1200
Carting	.0000
Feeding	.0300
Coal and oil	.0491
Engineer	.0200
Superintendence	.0250
Dynamite	.0300
Total	$0.4166

The wages paid for labor were as follows: Driller, $1.75 per day; helper, $1.50 per day; carts and man, $3 per day; engineer, $2 per day; coal, $4 per ton delivered.

All stone is weighed as it leaves the crusher, and the loads are tallied on their arrival at the street being paved.

HAULING.—The average haul was 1½ miles; average load hauled was 2½ to 3 tons.

The contract price for hauling was 32½ cts. per ton. The actual cost to the contractor was 26.6 cts. when drawn direct from the crusher bins, and 31 cts. if drawn from piles. The hauling was done by ordinary dumping wagons with teams at $4 per day. The method of hauling could be greatly improved and the cost lessened by the substitution of self-dumping and spreading wagons.

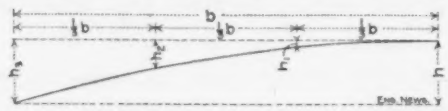
LAYING PAVEMENT.—The laying of the pavement was done by day work, the wages paid being $1.50 per day for laborers, $4 for teams with drivers, $3 for carts with drivers, $12 per day for roller with coal and engineer. The work consists in excavating and grading the street, rolling the foundation, spreading the stone, and sprinkling and rolling. The average cost of this part of the work by the square yard is as follows:

Excavating and grading	$0.0805
Spreading stone	.0258
Rolling stone	.0327
Sprinkling	.0028
Gutters	.0507
Total	$0.1925

The foundation at Hudson has always been a stiff yellow clay. No attempts have been made to lay subsoil drains, and rarely have we experienced any trouble through water.

In placing the macadam, 5 ins. of the largest sized stone, called No. 3, is placed and thoroughly rolled without any sprinkling; 2½ to 3 ins. of the medium sized stone, called No. 2, is next spread, sprinkled and rolled; about ¾-in. of the fine screenings, called No. 1, is used as a binding course. This course is sprinkled freely and rolled thoroughly. The street is usually opened to traffic immediately after this rolling is completed. The average amount of stone used is 0.3 tons to the square yard.

CROWN.—In fixing the amount of crown to be given any street the traffic forms the most important factor. Streets with heavy traffic are given low crowns, while streets of light traffic are given high crowns. The method of distributing the crown is as follows: The half width of the pavement is divided into three equal parts, as shown in the accompanying diagram:



Let b = ½ width of roadway, and h = total crown,

then

$$h_1 = (\tfrac{1}{3})^2\ h = \frac{1}{9}\ h,$$

$$h_2 = (\tfrac{2}{3})^2\ h = \frac{4}{9}\ h,$$

$$h_3 = (^3/_3)^2\ h.$$

This method gives a form of pavement that drains quickly and at the same time does not force the traffic to the center of the roadway. The amount of crown to be given any street is a matter of judgment, depending on the grade of the street and the amount of traffic. The greater portion of our streets are 30 ft. in width, from curb to curb, and have a crown of from 9 to 15 ins.

City Hall Place, Hudson, N. Y.—20 ft. Between Curbs.

The usual size of curb is 5 ins. by 20 ins. deep. Experience has taught that by setting the curb with a batter of about 1½ ins. per foot and making the gutter only 5 ins. deep, the alinement is not affected by the action of the frost, even when no underdrain is used. The average cost of laying a 4 × 20-in. quarry dressed curb is 35 cts. per lineal foot, and for a sawed curb, 50 cts. per lineal foot. The expense of furnishing and laying the curb is borne by the abutting property owner.

The average actual cost to the city per square yard of the finished roadway is as follows:

	Sq. yd.
Quarrying, blasting and crushing, by contract:	
Drilling and blasting	$0.01275
Dynamite	.00900
Loading	.03600
Carting to crusher	.02700
Feeding	.00900
Coal and oil	.01473
Engineer	.00600
Superintendence	.01050
Repairs and profit to contractor	.00402
Hauling:	
Hauling stone	.07980
Profit to contractor	.01920
Laying by day work:	
Spreading stone	.02580
Excavating and grading	.08050
Rolling	.03270
Sprinkling	.00280
Gutters	.05070
Total	$0.42050

It will be seen by the above that the profit to the contractor in quarrying and hauling was small; however, the contracts for both were held by the same firm, they using their own teams. $4 per day of ten hours was allowed for these teams in computing the above average.

The cut above is a view of City Hall Place, a 20-ft. street of medium traffic, having a crown of 8 ins., or 0.8-in. per ft. This street was laid by contract in 1896. The cost was 46 cts. per sq. yd.

Of the two views on the preceding page, the one on the left is a view of lower State St., a 20-ft. street of light traffic. The street was originally 40 ft. wide with 10-ft. sidewalks. In improving the street the width of the roadway was reduced to 30 ft., and 5 ft. on each side of the street was sodded and reserved for trees. The crown of this street is 15 ins., or 1 in. per ft. This macadam was laid by day work in 1900 at a cost of 42 cts. per sq. yd. The reduction in the width of the roadway in this block reduced the expense about 25%, besides greatly improving the looks of the street. There was considerable opposition to this plan at first on the ground that there would not be room to accommodate the traffic. The same persons who then opposed the change most strongly are now those who seem most enthusiastic over the success of the idea. This might be taken as an object lesson which goes to show that it is not necessary to macadamize to the full width on many of our wider streets. A narrower street between curbs, with wide sidewalks and grass plots, saves money for a city, and at the same time beautifies the block.

Of the two views on the preceding page, the view on the right is a view of Willard Place, a 25-ft. street laid in 1895. In the construction of this street the binding course used was black sand in place of the limestone screenings. The object in using the sand was as a binder to minimize the dust nuisance. There is little difference in this respect, however, at this date between this street and the streets where the limestone screenings were used.

SINKING AND EQUIPPING NO. 9 SHAFT, ASHLAND MINE.*

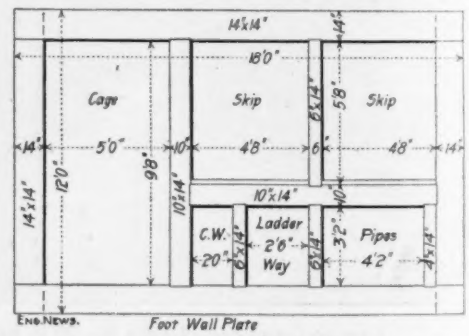
By H. F. Ellard.†

The sinking and equipping of modern shafts is ever an interesting feature of mine work.

The location of our No. 6 and No. 7 shafts, as well as their condition in May, 1901, made the sinking of a new shaft at this property a necessity. At that time, the mine was purchased by the Cleveland-Cliffs Iron Co., and this improvement was at once decided upon.

Upon assuming charge of local operations here on June 11 following, the attention of the writer was directed to this feature of the work. After a careful survey of general conditions, we commenced, July 15, to explore the foot-wall at the location most desirable, and by test pitting and diamond drilling, we determined that the ledge consisted of a layer of quartzite, almost uniformly 75 ft. thick, overlying strong quartz slates, both cut at different points at dikes of diorite, which in the unaltered form here encountered proved extremely hard material.

The drift consisted of 20 to 25 ft. of peat, sand and boulders. The diamond drill cut the measures at right



Plan of Timbering for No. 9 Shaft; Ashland Mine.

angles from the 1st, 3d, 8th and 10th levels, and proved the foot to dip to the north at an angle of approximately 60° from the horizon; this incline was, therefore, adopted for the shaft.

The location selected is a point 155 ft. in the foot-wall and immediately south of No. 6 shaft.

It was decided to sink a shaft of considerable capacity, as we wished to have it serve the territory formerly developed by Nos. 5, 6, 7, and 8 shafts. We, therefore, made provision for two skips, a cage and counterweight, a ladderway and pipe compartment. These with sufficient dividers called for a shaft 9 ft. 8 ins. × 15 ft. 8 ins.

*A paper read before the Lake Superior Mining Institute, August, 1903.
†Ironwood, Mich.

inside dimensions. The outside dimensions including laths required an opening of 12 ft. 4 ins. × 18 ft. 4 ins., but the ground actually broken was generally about 13 ft. × 19 ft. displacing 247 cu. ft. or 20 tons of rock per foot of sinking.

The sizes of the compartments, as shown in the accompanying cut, are as follows:

Cage compartments, 5 ft. × 9 ft. 8 ins.;
Two skip compartments, each 4 ft. 8 ins. × 5 ft. 8 ins.;
Counterweight compartment, 1 ft. 8 ins. × 2 ft. 8 ins.;
Ladderway, 2 ft. 6 ins. × 2 ft. 8 ins.;
Pipe compartment, 2 ft. 8 ins. × 4 ft. 4 ins., all inside dimensions.

The timbers used are as follows:
Wall plates and end pieces, 14 × 14 ins., white pine;
Cage divider, 10 × 12 ins., tamarack;
Divider for foot of skip compartment 10 × 12 ins., tamarack; all other dividers 6 × 12 ins., tamarack;
Cage runners, 5 × 8 ins., and skip runners, 6 × 7 ins., Norway pine;
Studdles, 12 × 12 ins., white pine.

To give additional stability to the divider carrying the skip roads without dovetailing it into the end pieces a studdle of 4 × 12 ins., tamarack, was added between this divider and the foot-wall plate. The other end of this divider was dovetailed one inch into the cage divider, and in addition to this is strengthened by the 6 × 12-in. dividers between the counterweight and ladder compartments. The size of the wall plates and end pieces was reduced to 12 × 12 ins. when the shaft had reached a point in the ledge where the ground was considered sufficiently strong to warrant this. The laths are 2-in. hemlock on the ends and foot-wall sides; on the hanging side 2-in. tamarack was used almost exclusively. A 3-in. tamarack floor was placed between the rails of the skip roads, and 45-lb. rails were used for the skips and cage. A casing of 2-in. plank on the skip side separates the cage and skip compartments. The sets were spaced irregularly. This was due to the nature of the material, which at the surface was very treacherous, and farther down became very hard and strong. The hangers are of 1¼-in. common iron.

The design as adopted proves very practicable, and the only feature which has not met with universal approval, and about which any misgivings were entertained at first, is the placing of the skips in the hanging. This, it was argued, would place an excessive load on the dividers carrying the skip roads, and also tend to weaken the construction at a time when the timbers would begin to decay. While recognizing the force of these objections, we maintain that with reasonably heavy rails, the burden of supporting the skips, and the skip roads on a 60° angle is comparatively slight, and the opportunities for reinforcing or renewing any of these dividers are such that the entire work could be done without causing the skips any delay whatever. The design lends itself admirably to the convenient and rapid handling of ore and timbers, and the pipes rest upon the foot-wall fully protected from jar or strain.

ORE POCKETS.—On each main level two small pockets, each holding one skip load are constructed immediately in front of the skips, and into these the ore is dumped by means of self-acting tipples. A level conveniently located is connected to a slide door, consisting of steel plate ¼-in. × 2-ft. 4 ins. × 3 ft., and this is readily raised by the skip tender when the skip is in position for loading. The incline of the shaft brings the skips directly underneath the doors and no waste whatever occurs in loading.

EQUIPMENT.—Pump stations were cut on the 7th and 10th levels, and two pumps installed in each. All of these are compound duplex pumps and provide a direct and relay reserve plant from the 10th level to the surface. We are now installing a new triple duplex pump on the 13th level and have added a pair of high-pressure boilers for this work.

As a precaution toward insurance against fires as well as to preserve the shaft timbers, a system of perforated pipes and galvanized iron baffle plates was placed in the hanging side, by which means a very small amount of water in continuous flow keeps the shaft timbers in a thoroughly saturated condition at all times.

The skips are of ordinary type for inclined shafts. They are of 72 cu. ft. capacity and equipped with single tread front and double tread rear wheels 12 ins. in diameter, of manganese steel, pressed on to 3-in. cold rolled steel axles running in self-oiling babbitted boxes.

The cage is, we think, unique in some of its features, and was designed especially for this shaft. It travels on a track of 4-ft. 3-in. gage on the foot-wall end of the compartment and consists of a cross-head, to which are attached safety clutches, sills and hangers, carrying the wheels, axles, shoes, floors, etc. There are two floors 6 ft. 6 ins. apart, supported in horizontal positions between the hangers. Each floor is 10 ft. 8 ins. long and 4 ft. wide in the clear, and the lower one carries a track of 1-ft. 10-in. gage, conforming to our mine and surface timber tracks. It is also fitted with a device for locking cars and trucks in place while on the cage. This is operated by either of two levers on the foot and hanging ends, respectively, of the cage floor. Guards serve to keep the men in place while riding on this floor.

The upper floor will be similarly fitted in time, but with the engines now employed for handling the cage, it is not deemed advisable to use both floors for loads. It is sometimes very convenient, however, to hoist rock or ore on this floor, and in such case the mine car is pushed off the cage, and dumped into the rock chute or either of the ore bins as desired.

All timbers up to 10 ft. in length are handled on small trucks, pushed into the cage from the foot-wall side. These are loaded in the timber yard and used to carry the timber up through the drifts on the levels without rehandling. Longer lengths of timber are swung by a crane, and lowered endwise through the upper floor of the cage to rest on the lower. The crane is also used to place the skips on and off the skip roads.

A length of 7 ft. on each floor is available for men and this furnishes standing room for 25 to 27 men.

The shoes run on 5 × 8-in. Norway pine guides, placed 4 ft. 10 ins. from the foot-wall. These serve as back rails for the cage wheels.

The safety clutches are attached to the crosshead and also run on these guides, and are depended upon to effectually prevent a runaway of the cage, should an accident occur to the hoisting cable.

The wheels are of manganese steel 16 ins. in diameter, pressed on to 3-in. cold rolled steel axles, running in self-oiling babbitted boxes. The lower wheels are placed below the floor and braces run from the sills at this point to the hanging end of the floor to add greater strength to the floor supports at this end, and also to thoroughly brace the entire lower frame work.

The weight of the cage with wheels and axles is slightly over two tons.

HEADFRAME.—The headframe was erected by the Wisconsin Bridge & Iron Co., Milwaukee, Wis. It is of steel and of very simple design. It contains two small ore bins with a combined capacity of 100 tons, fitted with pocket stops of the style as described in Volume II. of the "Proceedings" of this Institute by Mr. Wm. Kelly. To this, we added a slight improvement which enables the brakeman to operate the stop without leaving the railroad car. It consists of bending the handle or lever and attaching loosely thereto a supplementary handle, which in our case is nothing more than a canthook stock. This hangs loosely over the car within easy reach of the brakeman.

The landing platform is 42 ft. above the ground and the openings to the ore bins are opposite the skips. Small steel chutes carry the ore forward to discharge into these bins, and the grading is done by a special grading truck, which travels crosswise under the chutes and deflects the ore to one side or the other as is desired. It also throws the rock from the skip to the side of the ore bins into a chute which carries it to a rock car on a trestle 17 ft. below the landing platform.

Some of the features of the landing platform are as follows: Either grade of ore may be hoisted with both skips and the cage, and dumped into either of the ore bins or the stockpile car, as desired. Rock may be hoisted with one skip and the cage. When shipping and stockpiling are carried on simultaneously, both grades of ore may be hoisted for both purposes with both skips and the cage. All the work of this landing, including the grading of ores, the giving of signals, and the tramming of rock, is done by one lander. The rock is handled by an automatic side-dumping car, propelled by a small winze hoist, to which reversing gear was added. It is operated by the lander.

STOCKPILING.—When stocking ore, one of the chutes above mentioned is reversed so that the ore is discharged into two cars on parallel tracks. These run to two trestles, 60 ft. apart, and are propelled by a haulage plant of the "Four-Loose-Reversible-Drum" type, situated in the engine house and connected to the cars by ropes and sheaves in the ordinary way.

The cars are automatic as to the opening and closing of their doors. They have a capacity of four tons each, at a speed of 1,000 ft. per min. They are operated independently, but by one man. A suitable indicator on the haulage plant shows the positions of both cars at all times, and both cars may be propelled in either direction at the same time.

SINKING.—Ground was broken Sept. 23, 1901, and has been carried on at intervals since that date. The shaft was completed to the 13th level, a distance of 1,032 ft. on June 30 last. The work during the first few weeks was tedious, owing to an excessive rainfall and consequent caving of the hanging side, and to the customary delays in getting timber, hoist, headframe, buckets, etc., in position for work. Our pumping charges were very light, only 30 gallons of water per minute being handled in addition to the occasional floods above mentioned. Once fairly started, very fair progress was made. The timbering was very carefully done, one wall plate only was broken by blasting, and the shaft presents a thoroughly workman-like appearance. No serious accidents and no fatalities occurred during the progress of the work. For the first 87 ft. sinking was carried on in the regular way. Four miners were employed on each shift, and they drilled, shoveled or timbered as was required. They worked 8-hour shifts and were paid $2.50 per day.

Below this point with the exception of 47 ft. included in three winzes the entire length of the shaft was penetrated by raises. These were about 6 × 6 ft. in size, and placed as nearly as possible in the center and toward the foot-side of the shaft. There were six of these in all, varying in height from 112 to 200 ft.

The customary chutes at the bottom of the raises were dispensed with, and floors and openings the full width of the rock compartments were maintained to allow free discharge of the coarse work. A pole across the opening served as a stop in each case.

It was necessary to put in six cross-cuts from the old workings to the line of shaft, a total distance of 1,037 ft. In addition to the sinking crew two other gangs were employed most of the time, one raising and the other preparing the cross-cut on the level below.

Until the shaft went into commission, July 1, 1902, a foreman, our regular timber boss from the mine, spent most of his time at the work and looked after the framing and placing of sets, the moving of pumps, the care of tools, supplies, etc. After this time, the work was carried on continuously, one, two or three shifts being employed as conditions at other points warranted.

The sinking and timbering were done on the "Company Account" plan, the drifting and raising were done by contract.

Two Ingersoll-Sergeant rock drills, 3½-in. cylinder, were used. The air pressure was generally from 80 to 90 lbs. and 1¼-in. air hose was used. From 20 to 24 holes from 10 to 14 ft. in depth were drilled for each cut and 50% powder was used exclusively. Ammonia powder was used in raises and at all points where the ventilation was poor.

PROGRESS.—The work was necessarily carried on in sections, and in most cases very satisfactory results were attained.

The following table gives a summary of the work by sections, giving the length of same, the force employed, the time required to complete, and the time lost by sun-

Summary of the Work on Shaft No. 9, Given in Sections.

Section.	Length, ft.	Force, men.	Employed shifts.	Time to complete, weeks.	Time lost, hours.
1. Sinking from surface	87	13	3	9	101
2. Raising from 2d level	125	4	2	6	28
3. Stripping down and timbering to the 2d level.	125	13	3	6	12
4. Raising from 5th level	143	4	2	9	16
5. Stripping down and timbering to 5th level	143	3	3	6	20
6. Sinking winze below 5th level	20	6	3	1	12
7. Raising from 7th level	129	4	2	7	8
8. Stripping down and timbering to 7th level	153	13	3	5	..
9. Raising from 8th level	110	6	3	20 days.	..
10. Stripping down and timbering to 8th level	110	13	3	5	7
11. Sinking below 8th level	13	6	3	1	..
12. Raising from 10th level	157	4	2	11½	27
13. Stripping down and timbering to 10th level	157	12	3	7	8
14. Sinking below 10th level	14	12	3	1	..
15. Raising from 13th level	200	4	2	13	48
16. Stripping down and timbering to 13th level	230	12	3	10	20

Total raising 864 ft. in 50 weeks, or 2.88 ft. per day.
Total sinking 1,032 ft. in 50 weeks, or 3.44 ft. per day.

dry causes. This last item refers to the time lost by the total force employed on one shift.

COST.—The following statement shows the cost of the work:

	Per ft. Labor.	Per ft. Supplies.	Per ft. Total.
Sinking and stripping down	$12.15	$4.65	$16.20
Raising	6.19	1.64	7.83
Timbering	4.00	8.38	12.38
Skips, cage and ladder roads	1.74	2.45	4.19
Miscellaneous charges.*	1.06	1.07	2.13
Total	$25.14	$17.59	$42.73

*Including cost of temporary hoisting equipment and underground ore pockets.

Summary of Supplies.

	Per ft.
Explosives	$2.60
Iron and steel	1.34
Pipe and fittings	.48
Timber and lath	8.15
Steel rails	1.50
Miscellaneous supplies including fuel and air	3.52
Total as above	$17.59

The sinking and raising accounts include the cost of handling the material on the levels, hoisting and disposing of it on surface; also cutting out the plats on the levels. The timbering account includes the cost of timbering the plats.

It will be noticed that the timbering is a very expensive item, and I give herewith the cost of materials for one complete set:

Memorandum of cost of timber for No. 9 shaft, one set:

		Ft. B.M.		
2 pieces	12 × 12-18 pine	432		
2 "	12 × 12-12 "	288		
1 piece	12 × 12-16 "	192		
Total		912 at	$19.60	$17.33
2 pieces	10 × 12-10 tamrck	200 "	13.50	2.70
1 piece	6 × 12-12 "	72 "	13.50	.97
1 "	4 × 12- 5 "	20 "	18.00	.36
2-in. hemlock		545 "	11.50	6.27
2-in. tamarack		180 "	14.50	2.61
250 wedges, each			.01¼	3.13
1 cord soft wood				2.25
				$35.62
65 lbs. 1¼-in.	iron		$2.00	$1.30
35 " "	washers		1.85	.65
13 " "	nuts		.04½	.68
10 "	spikes		2.45	.25
				$2.88
				$38.50

To this we have to add the framing, teaming and shop labor, amounting to approximately $10 per set, making a total charge on the surface of $48.50 per set.

There are 198 sets of this size, and 17 sets of 14 × 14-in. timbers in all, the heavier timbers being used in the more treacherous ground near the surface.

To S. R. Elliot, engineer, and Capt. G. A. Anderson, in charge of the work, much credit is due for the accuracy and excellence of the work performed.

THE NEW YORK RAPID TRANSIT RAILWAY.

XXIV.

Contract Section IX-a; Harlem River Tunnel.*

The line of the subway up Lenox Ave. leaves that avenue near 143d St. and curves easterly so as to cross the Harlem River in a northeast and southwest direction, almost adjacent to the southeasterly side of the 145th St. bridge. A double-track tunnel with the lowest base of rail 44.66 ft. below mean high water is used for the river crossing. The distance between the river bulkhead lines is 400 ft. The tunnel for this distance of 400 ft. and for a distance of 85 ft. on the Manhattan side and 125 ft. on the Bronx side of the bulkhead lines, making a total of 610 ft. in length, consists of two cast-iron circular cylinders embedded in a concrete envelope, the centers of the cast-iron cylinders being 12.5 ft. apart. As the diameter of each cylinder is 16 ft., it will be seen that the complete circles of the cylinders overlap each other, so that a vertical diaphragm separates the two tunnel lines. The approach tunnel on both the Harlem and the Bronx sides of the river consists of one double track opening with the tracks the same distance apart c. to c. as in the cast-iron cylinders. These approach tunnels, together with the two-cylinder portion under the river and the bulkheads, make a total length of 1,500 ft. The base of rail at that end of the tunnel nearest Lenox Ave. is 24.58 ft. below the surface, and at about the same distance at the Bronx end. There is a down grade, therefore, in approaching the river tunnel from either direction amounting to 3%.

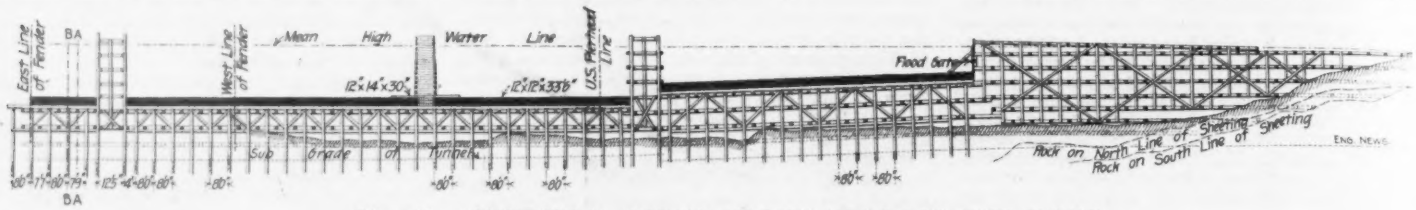


FIG. 111. LONGITUDINAL DIAGRAM SECTION OF HARLEM RIVER TUNNEL.

The depth of water in the Harlem River at the tunnel crossing is about 26 ft. at mean high water, with a mean range of tide of about 5 ft. The material in the bed of the river down to subgrade, a maximum depth of 47.65 ft. below mean high water, consists of the characteristic Harlem River mud, silt and sand, the latter flowing with remarkable ease when wet. The same material is also found on either side of the river for a distance of 200 to 300 ft. back from the bulkhead. It will, therefore, be evident that nearly the entire tunnel line, taken from one extremity to the other, has had to be carried through material which at many points is the most difficult to deal with and the most unstable ever met in tunnel construction. Some of the mud found was fairly stiff for such material, but most of it was soft and even flowing almost with the facility of a liquid. Similarly, some of the sand encountered was good material of its kind, but by far the larger portion of it was what might be deemed quicksand, if any one can define precisely what that is. In this case it is material which when filled with water is exceedingly insidious and penetrating whenever an opportunity for leakage or for movement of water occurs. The problem before the subcontractors, Messrs. McMullen and McBean, was, therefore, the devising of some plan of construction by which the subway tunnel could be carried through the most treacherous material encountered in subaqueous construction with reasonable economy and in perfect safety.

The plan devised by Mr. D. D. McBean of the subcontracting firm doing the work consists mainly in enclosing the space or volume to be occupied by the completed tunnel by a heavy line of specially-constructed 12-in. sheet piling on each side, and a roof supported upon those two side lines of sheeting consisting of three layers or courses of timber 12 ins. thick, each adjacent two courses being separated by a course of 2-in. plank running at right angles to the 12-in. timbers, thus making a total thickness of about 40 ins. The heavy timber enclosure, consisting of the two lines of sheet piling and timber roof, was so designed by the subcontractors that if desired or found feasible, excavation of material within it and the final construction of the tunnel could be made at atmospheric pressure. On the other hand, the plan was also carefully developed so as to be adapted to the use of compressed air in the ordinary way, if it should be found advisable to resort to it.

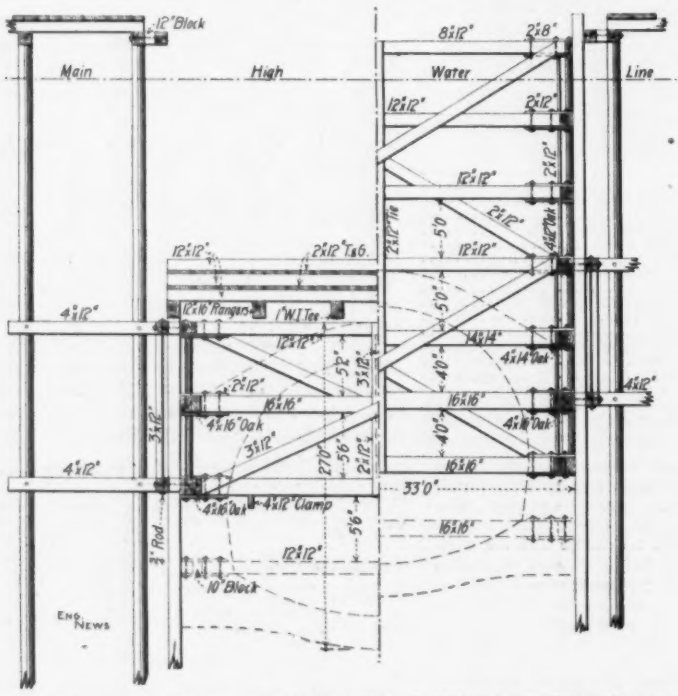


FIG. 112. TRANSVERSE SECTIONS THROUGH DOUBLE-TRACK CONCRETE TUNNEL.

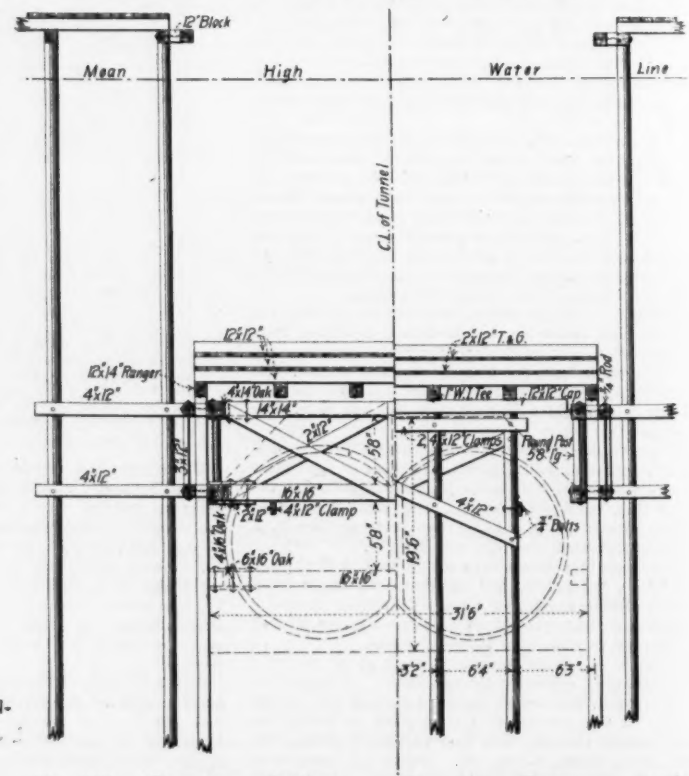


Fig. 113. Transverse Section Through Double-Tube Tunnel at A A.

Fig. 114. Transverse Section Through Double-Tube Tunnel at B B.

It was supposed that it would be necessary to use compressed air in that part of the construction under the Harlem River, but it was not considered necessary to do so for those portions of the tunnel on either side of the river, and subsequent events have justified the supposition.

When the plans for the work were begun it was considered advisable to contemplate the use of the

*Written for Engineering News by Prof. Wm. H. Burr, M. Am. Soc. C. E., Consulting Engineer for McMillen & McBean.

timber roof resting upon the side lines of sheeting for those portions of the tunnel on either side of the river flanking the bulkhead lines. As the efficiency of the plan became more evident, however, the subcontractors decided that it would be both safe and judicious to construct those portions of the work in the open excavation between the lines of sheeting without the use of the timber roof, and that has been successfully accomplished, although the depth to which the excavation was carried on the Manhattan end was as much as 52 ft. below extreme high water at the deepest point.

Figures 112, 113, 114, 115 and 116 show, respectively, three cross-sections of the work, to which reference has already been made, one plan and one longitudinal profile. The outlines of the cross-sections of the completed tunnel on the Manhattan side of the river are shown in Fig. 112, while Fig. 113 shows the cross-section of the cast-iron lined portion under the river. Fig. 115 shows the longitudinal profile of the timber roof, as well as the piles, certain portions of the bracing and the bulkhead used between the river and the approach portions, and a timber shaft for the air lock and pumps used in the river portion. Fig. 116 shows the general plan of the timber work and the staging built on either side for service during construction. These five figures exhibit completely not only the main features, but the details of the entire work. Inasmuch as the construction of the tunnel had to be conducted in such freely moving material, the side pressure of the water, mud, silt, and sand was excessively high, requiring unusually heavy and well-designed bracing to keep the sheeting in place. This bracing, as will be seen later, was on two or three occasions subjected to extraordinarily severe tests and it performed its duty in such a highly satisfactory manner as to afford no point of material criticism.

As the original intention was to construct the entire tunnel in the closed timber chamber, that chamber will first be described. The initial step in the operation was the dredging of the material along the tunnel site, as shown by the broken line in Fig. 115, to such an extent as to leave an average depth of about 7 to 8 ft. to be removed in the chamber. It was expected that the remaining material with that between the bed rock and the bottom of the finished structure would certainly hold the lower portion of the timber sheeting firmly in place. In the main that expectation was realized, but at one point, as will subsequently be seen, the material below the sheeting was washed out by an inrush of water.

After the dredging was completed, four longitudinal rows of piles were driven hard to refusal so as to be distributed uniformly under the completed structure, these rows of piles being placed 6 ft. 4 ins. apart, centers transversely. The piles in each row were 8 ft. apart centers. These piles were cut off under water so as to bring their tops about 11 ft. above the center of each cast-iron cylinder and were then capped with 12-in. x 12-in. sticks, as shown in Fig. 113. The functions of these piles were first to support the heavy timber roof, about to be described, and aid in placing and securing the bracing frame, and eventually to be cut off at subgrade for the purpose of aiding in the support of the finished structure, if such support should be needed in consequence of soft material.

Before cutting off the piles they were drawn into line as accurately as possible by a pair of transverse timbers held together by bolts above the water. A similar pair was slipped loosely down the bent to a proper elevation a little below that at which the piles were to be capped, the bolts of these latter sticks being drawn tight by a diver. After the piles were cut off this procedure of alinement was found to be markedly successful, so that the caps were put in place with the required accuracy without serious difficulty.

The accuracy of alinement of the two series of sheet piling, one on either side of the structure, was secured with great precision by a substantial pile platform on either side of the site of the tunnel, used as service platforms in the progress of the work, and by a timber frame accurately constructed to fit closely between the two lines of sheeting, the center line of which lay precisely in

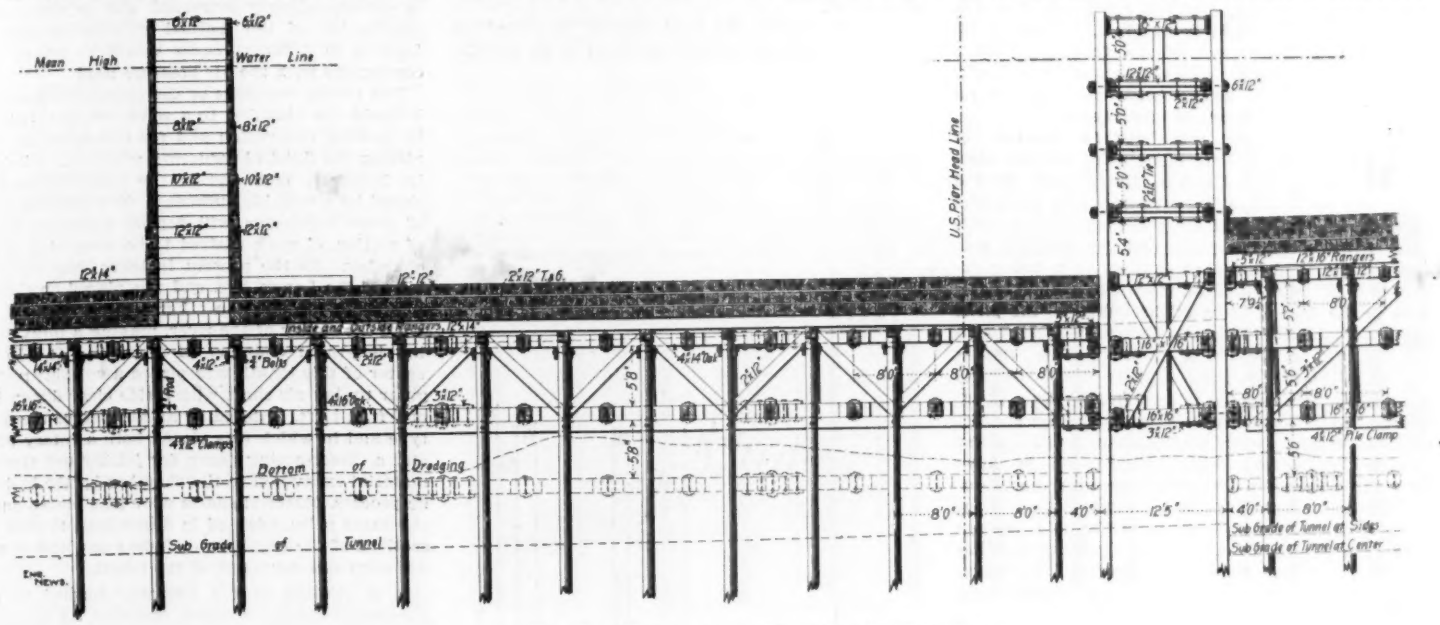


Fig. 115. Part Longitudinal Section

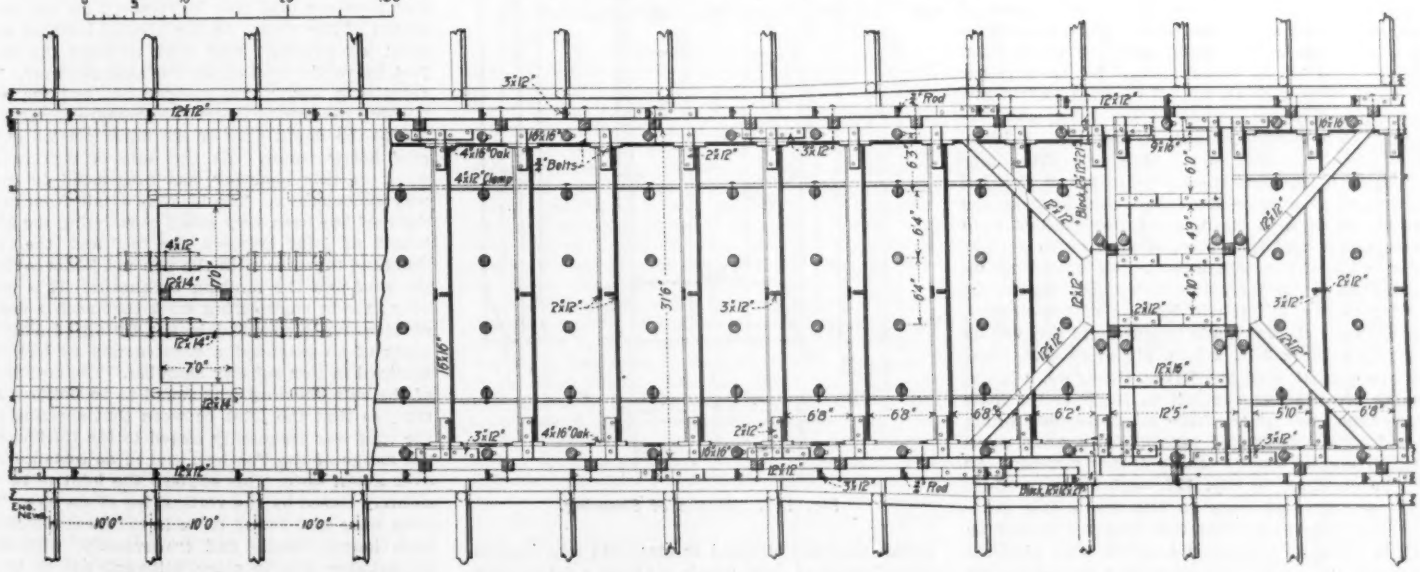


Fig. 116. Sectional Plan.

FIGS. 115 AND 116. PLAN AND PART LONGITUDINAL SECTION, SHOWING TIMBER ROOF, BULKHEAD AND WORKING SHAFT.

the vertical plane through the axis of the tunnel. Figs. 112 and 113 show the cross-section of those portions of the pile platform immediately adjacent to the two lines of sheeting and the accurately-built timber framing between those lines. The latter frames for the river portion were constructed of two vertical tiers of longitudinal timbers, the upper tier being of 14-in. × 14-in. and the lower of 16-in. × 16-in. timbers held 6 ft. 11 ins. apart centers by round sticks and bolts in the ordinary manner. This longitudinal series of sticks was held apart horizontally by 14-in. × 14-in. and 16-in. × 16-in. timbers strongly bolted and braced, as shown in Fig. 113. Twelve-inch square timbers were bolted to the longitudinal 14-in. × 14-in. and 16-in. × 16-in. sticks with 12-in. blocks between, all as shown clearly in Fig. 115. The presence of these 12-in. blocks secured a 12-in. space on either side of the framing, within which the sheeting already described was finally driven, the 12-in. blocks being removed as required in the progress of the driving.

This timber frame was built in lengths of about 216 ft. at a ocnvenient point on the easterly shore of the Harlem River and floated into the open space between the pile platforms prior to the driving of the sheeting. While floating between the pile platforms this framing was accurately lined and then sunk so as to bring the 14-in. and 12-in. longitudinal sticks exactly opposite to the 4-in. × 12-in. sticks bolted to the piles, as shown in Fig. 112. As shown in section also in Fig. 112, a 12-in. × 12-in. longitudinal timber was also bolted through a 12-in. block to the longitudinal cap of the pile platform. This 12-in. timber with that vertically below on the sunken frame formed perfectly accurate guides along which the sheeting was to be driven. In other words, the sunken timber frame and the 12-in. sticks at the top of the pile platforms formed an absolutely accurate guide on either side for the line of sheeting, thus insuring that the position of the latter should be exactly correct. The cast-iron lined concrete tunnel could then be built with the vertical sheeting on either side as a mold.

After the timber frame was put in place the work was ready for the driving of the two lines of sheeting. This sheeting consists of 12-in. × 12-in. long leaf yellow pine sticks generally 65 ft. long. Three such sticks were solidly bolted together so as to form a single unit 3 ft. wide and 12 ins. thick made wedge-shaped at the lower end, except that a portion of one of the 12-in. × 12-in. sticks was brought to an edge at right angles to the 36-in. dimension. By reference to Fig. 116 it will at once be evident that this form of the lower end of each 36-in. sheet pile enabled it to drive easier and at the same time made a tight joint with the adjacent piece by crowding up against it in the operation of driving. Again, referring to Fig. 117, it will be seen that each such 36-in. sheet pile was made tongued and grooved by suitably spiking 3-in. × 4-in. pieces on each edge. By one operation of the driver, therefore, a 38-in. length of sheeting was put in place and a little more than two-thirds of the joints avoided which would have existed had each 12-in. × 12-in. stick been driven by itself in the ordinary manner. As will be observed in Fig. 117, each 12-in. × 12-in. stick was dressed truly to 11¾ ins. × 11¾ ins.

It was imperative that this sheeting should be put in place as nearly as possible with absolute accuracy, which was accomplished by employing the carefully-framed timber structures already described and the use of pilot piles. The pilot piles were built of steel channels and plates and were approximately 12 ins. × 12 ins. in outside dimensions of cross-section and 60 ft. long. These piles were fitted with pipes running down through their interiors and the pile points so that jets of water could be employed to wash away the material when they were being driven. Three of these pilot piles were first driven accurately in the position to be occupied by the sheet piling already described. They were then drawn and the timber sheeting immediately driven in their places down to rock or as near thereto as could be reached. In this manner the presence of boulders could be determined, if there were any, and means afforded for their removal before placing the timber or sheeting in position. Similarly, if any other obstructions existed or if there was any inaccuracy in the driving of the pilot piles, means could be taken to remove such obstructions or to secure the required accuracy of position of the timber sheeting. In other words, the use of these steel pilot piles prepared an unobstructed place in which the timber sheeting could be driven with absolute accuracy without any injury whatever to the timber. The success of the method was largely dependent upon the use of these pilot piles.

This sheeting was carefully cut off under water at the proper elevation by a circular saw operated from a pile driver. The subsequent examination of this joint at the top of the sheeting, after the chamber was unwatered, showed that the operation of cutting off the sheeting was completely successful.

Fig. 114 shows the roof already described as formed of three transverse layers of 12-in. × 12-in.

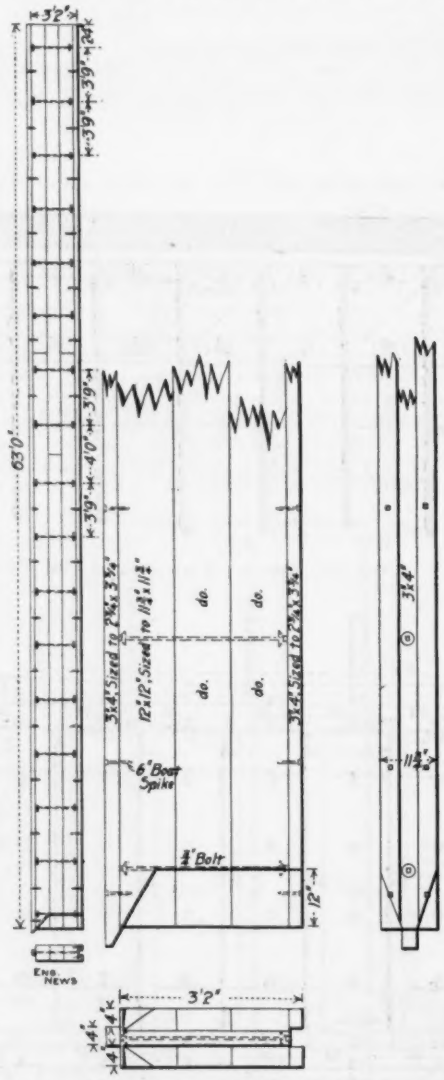


Fig. 117. Details of Sheeting.

sticks carefully dressed to size, and two longitudinal layers of 2-in. plank, making a total thickness of 40 ins. These three layers of timber and two layers of plank were thoroughly bolted together and calked so as to make a roof covering as nearly air tight as practicable. The sections of roof were constructed in lengths varying from 39 ft. to 130 ft., at a convenient point on the Harlem River and floated into place between the pile service platforms and over the framework and piles already fully described. As the plans show, six lines of 12-in. × 14-in. range timbers were bolted to the under side of the timber roof, thus affording supports for the latter immediately over the piles and the two lines of heavy 12-in. sheeting, as clearly shown in Fig. 114. The timber roof was sunk accurately to place, being properly guided, so that the two outer lines of rangers settled accurately down upon the two lines of sheeting cut-off at the proper elevation. As also shown in Fig. 114, the joint between these two outer lines of rangers and the top of the heavy sheeting was closed by Tee irons, the web of which being vertical cut into the tops of the latter as the weight of the roof settled upon them.

After this 40-in. thick roof had been accurately sunk to place and supported by the side lines of sheeting, it was overlaid with about 5-ft. thickness of earth or mud taken from the immediate vicinity of the work, so as to bring it down to a firm bearing, both upon the sheeting and upon the piles; the same load of filling also afforded weight against which compressed air in the chamber could act without displacing the roof. Obviously, any amount of air pressure could be forced into the chamber if the loading on the roof is correspondingly increased, and in the general application of the method varying amounts of loading in different cases would be required to correspond with the air pressure used.

The proper sequence of the operations described brought the chamber to a condition of actual use in making excavation and for subsequently completing the finished structure within it. Obviously, however, each end of the chamber must be closed by a suitable bulkhead. The distance apart of these bulkheads will depend upon the length of section of work desired to be completed in one chamber. In the present instance, one bulkhead toward the Lenox Ave. end was placed on the city bulkhead line and the other a short distance beyond the center of the river, making a total working length of chamber of about 216 ft. In the center of this length was placed a suitable rectangular timber air shaft with inside clear dimensions of 7 ft. × 17 ft., entered by an air lock of the usual type and in which was placed both a rotary pump and a direct-acting pump for jetting out the soft material excavated in the chamber by the hydraulic process. Material shafts were also placed one at the same point adapted in dimensions to pass the sections of the cast-iron cylinders and one at each adjacent quarter point of the length.

It is obvious that a chamber formed in this manner is capable of being operated, as far as the air pressure is concerned, at any depth and at any pressure that may be required for the prosecution of the work. In the present instance sufficient air pressure was used to force the water just below the roof of the working chamber. The remaining water was pumped out and the work is being performed under the pressure corresponding to the depth only of the lower portion of the roof below water. At the date of writing, the work in this chamber has progressed in every way successfully. The leakage of air from under the roof has been very small considering the great length of joint between the roof and the side sheeting, together with the two end joints between the roof and the limiting bulkheads. It is probably rare in engineering work that such a degree of accuracy is reached in the fitting of different parts of so extended a construction as has been attained in this subway chamber. The cutting off of the side sheeting was found to be uniform and true, so that the joint between that sheeting and the roof was frequently closed to the thickness of the flange of the Tee iron and in no instance was over about ½-in. This enabled the joint to be absolutely closed by the vertical leg of the Tee. The piles were also found to be in excellent alinement both longitudinally and transversely, with caps remarkably true in place, although put on under water by the aid of a diver. Their uniform distribution over the entire area of the chamber affords absolutely effective support for the roof in case of accident, besides giving useful means for bracing and other operations required in the work. As the tunnel is built within the chamber the piles are cut off so as to give effective and unyielding support for the finished structure. The entire experience of this construction has demonstrated this system to be unusually safe and effective for subaqueous tunneling in probably the most treacherous material encountered in this difficult class of work.

The preceding method as indicated has been followed for that portion of the tunnel under the river and for a short distance either side. The heavy sheet piling proved to be so effective and was found to be so satisfactorily placed that the

subcontractors concluded to omit the use of the roof for those sections of the tunnel flanking the river portion. The first part of the work undertaken in this manner was on the Manhattan side of the river, at the northerly end of which was the bulkhead 12 ft. 3 ins. wide over all formed of the same 12-in. sheeting already described, and filled with suitable material.

The cutting-off of the sheeting on this length of tunnel was therefore omitted. The timber framing constituting the guides for the sheeting and other requisite timber struts placed below the forms, after unwatering constituted the necessary bracing for the sides of the open enclosure. The bulkhead formed the dam at the river end of this section, and the natural rock at the other.

The entire cofferdam opening was readily unwatered and showed very little leakage. Excavation was then carried down to the required depth for the beginning of the construction of the tunnel, having the greatest depth of 52 ft. at the bulkhead at extreme high water. The material was mud, silt and sand, much of the latter being very fine and quick when filled with water. Nearly the entire excavation was completed when the water broke in at the northwesterly corner at the junction of the sheeting with the bulkhead. As the sheeting extended from 15 to 17 ft. below the surface of the material remaining within the enclosure, it was supposed that such an inrush of water was scarcely possible. Although the sheeting was driven practically to refusal by a 6,000-lb. hammer, some of it stopped from 5 to 8 ft. above the rock, and the pressure of the water from the outside was great enough to force a way through this opening and fill the enclosure. The heavy timber framing was, however, a complete safeguard against any sensible horizontal displacement of the sheeting and the latter was immediately driven down through the disturbed material to what was supposed to be rock. In this operation some of the pieces of sheeting were driven 8 ft. lower than at first, and others but a few inches. These operations caused only a few days' delay when the enclosure was again unwatered and the work of excavation again proceeded. The disturbance of the material around the outside of the bulkhead and sheeting at the northwesterly corner of the enclosure, made that point a weak one and again the water forced its way under the sheeting and filled the enclosure a second time. The sheeting was again driven, but in no instance could a piece be moved more than a few inches. This additional driving, however, was sufficient to close the sheeting down on the rock at all points. Other measures outside the bulkhead, such as additional filling, and forcing cement grout into the material around the foot of the sheeting, were employed to strengthen this portion of the work. After the third unwatering the excavation proceeded to completion and the tunnel was constructed within the enclosure without further incident.

These two inrushes of water demonstrate the quick character of the material into which the sheeting was driven, and how necessary it was that the sheeting should be carried actually down to rock. The force of the current underneath the sheeting was shown by the fact that bags of sand were carried by it underneath the toe of the sheeting from the outside into the enclosure, and even lodged on some of the lower interior bracing timbers. In spite of all that took place during these violent inrushes of water, there was no sensible displacement of sheeting or of bracing between, except the natural settlement in a vertical direction, so that in no instance was it necessary to do anything more than drive the sheeting to the additional depth permitted by the disturbed material and insert a few pieces of additional bracing. With these simple measures completed, the work progressed according to the schedule laid out for it. The entire experience with this method of procedure has been most gratifying, and shown it to be safe and effective under most trying conditions.

The northeasterly half of the tunnel is being constructed in precisely the same manner, but with the advantage of the experience gained in the southwesterly half.

The timber working chamber of the roofed portion of the tunnel has proved to be so tight and satisfactory that it obviously might be practicable to conduct the work in it at atmospheric pressure. It would only be necessary in that event to design the roof, pile-work and bracing to carry the loads and perform the duties corresponding to the absence of compressed air. In many locations that procedure might be advisable.

AN EFFICIENT HIGH-PRESSURE WATER-POWER PLANT.*

By G. J. Henry, Jr.,† Assoc. Am. Inst. Elec. E., and J. N. Le Conte,‡ Assoc. Am. Inst. Elec. E.

An interesting hydraulic power plant has recently been started in southern California by the Edison Electric Co., of Los Angeles. The water pressure or head employed is equal to 1,960 ft. vertical fall, which is obtained in something over 8,000 ft. length of pipe line. This gives an effective pressure—after making allowance for friction loss—of considerably over 1,900 ft. head, or 825 lbs. per sq. in., equal to 55 atmospheres.

The station is located about ten miles from Redlands, in southern California, and is used on an extensive system, including a number of other power stations, for transmitting power to Los Angeles and largely for irrigation pumping in the San Gabriel Valley, celebrated for its oranges and other tropical fruits.

The generators are of 750-KW. normal capacity each, running at 430 r. p. m., and the water wheels are of the tangential type and mounted on the same shaft as the

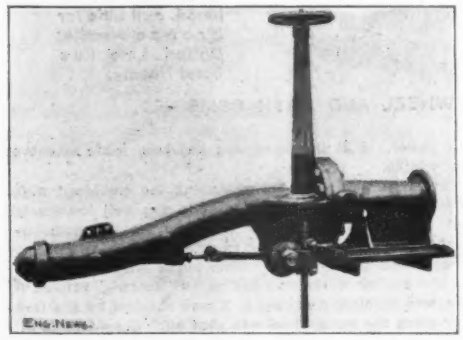


Fig. 1. Combination Deflecting and Needle Nozzle Showing Hand-Operating Connections for Needle.

rotor. This shaft is 9 ins. in diameter where the wheels are pressed on, and is of forged steel, carried in three ring-oiling bearings—the water wheel being located in what would ordinarily be the pulley compartment of the generator. The box bed-plate of the generator is enlarged to surround the water-wheel pit, and has an opening of 3 ft. 4 ins. × 10 ft. 2 ins., and is planed and fitted along water-tight joints with the water-wheel housings. These are thoroughly stiffened with internal ribs and provided with centrifugal disks and pockets for preventing leakage of water from the interior of the wheel compartment to the outside, entirely without friction.

Each water wheel is fitted with a single wheel or runner, which, on account of the enormously high peripheral speed of 170 ft. per second, is made of a special rolled-steel plate, thoroughly annealed and turned to eliminate all shrinkage strains. The high speed involved is entirely beyond the limits of safe practice for cast iron, and large cast-steel disks contain such dangerous shrinkage strains, in spite of the ordinary annealing process, that it becomes dangerous to employ them under such high water pressures. In addition to the centrifugal strains in the rim of a wheel of this character, we have the strains due to water impact on the buckets. This amounts to about 22,000 lbs. on the front bolt of each of the buckets. The buckets are of soft open-hearth steel castings, thoroughly annealed and machine ground, and polished on the inside to give perfectly smooth and true curved surfaces for the water to flow over. The front edge and center knife of each bucket are dressed to a perfectly true cutting edge and carefully centered on the wheel rim. The buckets are cast with heavy internal projecting lugs, which are milled out and driven over the wheel center rim. The wheel hubs consist of heavy semi-steel castings, to which the steel disk is securely bolted by turned nickel-steel bolts driven in reamed holes. This disk is turned perfectly true all over, and carefully adjusted to a running balance at 430 r. p. m. In actual operation about 200 buckets come under the action of the high-pressure water jet every second.

The wheels were built for a maximum overload capacity of 50%, and for continuous service of 24 hours a day and 365 days in the year, and no trouble is experienced from the cutting of the buckets and nozzles by the high-pressure water, as after five months' operation the wear is almost imperceptible. The water is usually clear, except for an occasional storm, during which considerable sand and gravel may be washed down into the reservoir at the top of the pipe line. The most severe storm known for many years washed considerable sand down the pipe line just after the wheels were installed and started up, but the steel buckets show no appreciable wear as the result of such severe treatment.

The main pipe line consists of: 2,485 lin. ft. of 26-in. inside diameter sheet-steel riveted pipe, varying in thickness from 14 b. w. g to 6 b. w. g., and below this 2,990 lin. ft. of 24-in. inside diameter sheet-steel riveted pipe, made of gages running from No. 6 b. w. g. to 9-16-in. Up to this point the design of the pipe line is largely in accordance with well-known practice, but from this point down the pipe consists of 300 ft. of 24-in. out. diam. ½-in. lap-welded steel pipe, 260 ft. of 24-in. out. diam. 9-16-in. lap-welded steel pipe, 414 ft. of 24-in. out. diam. ⅝-in. lap-welded steel pipe, 956 ft. of 24-in. out. diam. ¾-in. lap-welded steel pipe, 620 ft. of 24-in. out. diam. ⅞-in. thick, lap-welded steel pipe.

The 20-ft. lengths of the last 620 ft. are jointed together with solid steel flanges welded on the ends of the pipe sections, all of the other 24-in. lap-welded pipe being put together with "bump" joints.

At the lower end of this flanged pipe the line branches into two forks, each of which is 18 ins. outside diameter of ⅝-in. thickness, and 45 ft. in length. From each of these terminals the pipe again branches into two lines, each being 14 ins. outside diameter and ½-in. thick, lap-welded—each branch being 40 ft. in length and terminating just outside of the power-house wall in the cast-steel taper pipe immediately above the gates of the water wheels. The branch from the 24-in. to the 18-in. and the two branches from the 18-in. lines to the 14-in. are made of heavy annealed-steel castings. The main pipe line, just before the cast-steel Y to the 18-in. branches, is supplied with a heavy-pressure outside-screw and yoke 24-in. gate valve, and each of the 18-in. branch lines are supplied with similar high-pressure cast-steel valves so that the water supply to each water wheel or group of water wheels may be entirely shut off without emptying the long pipe.

The main pipe is protected from accidental water hammer by several air chambers of large capacity, with the necessary equipment of charging tubes to recharge the chambers as the air is carried away in solution. The 14-in. branch pipes supplying each unit feed through a cast-steel taper pipe and through a 10-in. single disc cast-steel body gate valve of outside screw and yoke construction, with Tobin-bronze valve stem and with roller bearings for taking up the thrust on the gate-nut in each direction. All of the gate valves are provided with by-passes to reduce the strain when the gates are opened or closed.

The nozzle is one of the most interesting features of the installation. It consists of a combination needle and deflecting nozzle. The deflecting joint is used for giving the best possible regulation without water hammer or shock in the pipe line, while water economy is secured by the needle nozzle of the Clemmons type. The deflecting nozzle is fitted with a high-pressure ball joint pivoting on nickel steel trunnions, working in oil-packed gun-metal bushings and with leather-packed ball joint. By the motion of the deflecting nozzle the stream may be easily thrown on or off of the buckets by hand, or automatically by the hydraulic governor. It will be readily appreciated that this enables the operator to vary the power output from the wheel from zero to maximum instantaneously and with very small effort, without in any way varying the velocity of water in the main pipe. Absolutely no shock is thus occasioned in the pipe line by the action of the governor due to fluctuations of the load. The most accurate regulation is further obtainable owing to the very

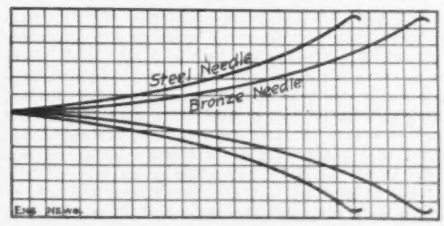


Fig. 2. Outlines of Needles Used in Tests.

small amount of inertia in the moving parts—the deflecting nozzle joint weighing but a few hundred pounds and being accurately counterbalanced—whereas in turbine installations the unbalanced gates and the inertia of the moving water column seriously interfere with satisfactory regulation. The governor is in no way conected with the operation of the needle, which is for the purpose of regulating the flow of water through the nozzle at different hours of the day, and is accomplished through suitable geared connections to a floor stand located above the

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power-house floor. The nozzle and needle connections are shown in the view Fig. 1.

The method of operation is as follows: From previous records the station attendant knows very closely the peak load that is likely to occur within the hour, and, once an hour, or thereabouts, readjusts the size of the stream so that it will safely carry the peak load. The governor then takes care of the load fluctuations, maintaining a constant speed at all times by deflecting more or less of the stream from the water-wheel buckets. In this way a very great saving in water over the old deflecting nozzle when used alone is obtained.

It is obvious that the best possible regulation and water economy could be effected without shock to the pipe line if the needle is moved very slowly and follows the action of the governor, closing off some of the water whenever the governor has deflected the nozzle, or opening quickly if the governor calls for more power. The quick opening will not interfere with our pipe safety, whereas quick closing by the needle would be disastrous to a long pipe line under high pressure. With the hand-operated needle and automatic governor-operated deflecting nozzle, this can only be accomplished to a limited degree, as the station attendant cannot be expected to remain at the hand wheel and adjust the size of the stream for frequent governor changes. In some of the most recent plants being constructed we are installing an automatic device for accomplishing this result. This device depends upon the action of the governor before starting its operation and, in combination with the governor, secures the best possible regulation, pipe safety, and water economy. The load curve and water quantity curve being almost synchronous, the quantity of water used is about proportional to the output, and exactly so if we leave out of consideration the partial load efficiency of the apparatus. These partial load efficiencies are, however, a very small item in a station employing a number of units and the governors should be adjusted so that they follow each other in action—all but one unit being run full loaded, and governing being accomplished on the remaining unit. A small falling off at partial load efficiency on the unit doing the governing will then represent but an extremely small reduction in the gross efficiency in the whole station.

For obtaining reliable data for use in the future design of water wheels some very careful measurements were made on the efficiency and output of these wheels and the results are appended herewith.

Although the plant is being used for regular service, it is to some extent in an experimental condition, as, in spite of the high efficiency obtained, some changes are being made with a view, if possible, of still further increasing this. It will be understood that the efficiencies given, exceeding 86%, are the gross efficiencies of the water-wheel equipment, including the losses in the gate-valve and nozzle, the windage of the wheel, and such slight losses as occur in the buckets. When we consider that the total losses of this type of water-wheel appartus summed together amount to but a little more than 13% of the theoretical enegry in the water, it will be readily appreciated that the results are extremely high, and can scarcely be surpassed by any other prime mover. The thoroughly satisfactory and continuous operation obtainable from such a tangential water-wheel plant, makes it by far the most satisfactory power known for electric transmission. The maintenance and repair expenses for a plant of this character are almost negligible.

The units are separately excited from a generator driven by an independent water wheel and from a separate pipe line, supplying only the excited wheels during the test. The object of the tests was to determine the efficiency of the wheel for different loads and styles of nozzle tips. The needles used in the needle nozzles are shown in outline in Fig. 2.

ARRANGEMENTS FOR TESTS.—All the water delivered by the wheel under test, as well as that delivered by the exciters, was passed over a rectangular weir of ample capacity. The discharge from the exciter alone was passed over another rectangular weir first, hence the water used by the wheel under test was deduced from the difference of flow over the two weirs. The output of the wheel was determined by the electrical output of the generator, whose efficiency was given by the manufacturer down to half load.

The effective head on the wheel was determined by the survey of the pipe line corrected by the frictional drop as deduced from the dimensions of the pipe line. This correction is so small as to be almost negligible for the quantities used, in fact a 1,000-lb. gage located 40 ft. above the nozzle showed no appreciable change between the static head and the effective head when one unit was running full power. Still the correction has been made whenever appreciable.

The large weir used for measuring the combined water of the main water wheel and exciter was well constructed and located, though rather too wide for the quantities used. The bay above was so large as to make the velocity of approach inappreciable. The small weir for measuring the exciter water was not so well located, but, as its flow was absolutely constant, it was checked by the large weir when the main wheel was shut off. Considerable difference was observed between the measure of this latter quantity as given by the two weirs, therefore that deduced from the large weir has been adopted in the following calculations.

The output of the switchboard was measured by two watt-meters, each of which gave the whole output. One of these was an indicating watt-meter, and the other an ordinary recording instrument. The results as given by the two did not agree for all loads, being about equal at 400 KW., above this the latter reading in excess, and below the former. In the calculations which follow, the results given by the recording instrument have been taken, that being considered the more reliable. The efficiency of the generator is taken as given by manufacturer as: 95.6% at full load; 95% at three-quarter load; 92.1% at half load.

Calling the generator efficiency E, we have—

$$\text{HP. wheel input} = \frac{\text{E. HP.}}{\text{E}} - \text{Exciter HP.}$$

As the field excitation of the machine is 97 amperes at 70 volts, about 6.8 K-W. are lost in the field, and the equation becomes:

$$\text{HP. wheel input} = \frac{\text{E. HP.}}{\text{E}} - 9.$$

Wheel efficiences depending on switchboard instruments cannot be considered as absolute and can only show in a general way the relation between efficiencies under different conditions.

The following constants and formulæ have been used in the calculations:

Static head = 1,923 ft.
Width of large weir = 8 ft. 11-64 in.
Width of small weir = 4 ft. 0¼ in.

The quantity of water has been computed by Smith's formula:

$$Q = \tfrac{2}{3}\, c\, b\, h \sqrt{2\, g\, h}$$
$$= \tfrac{2}{3}\, c\, b\, h^{\frac{3}{2}} \sqrt{2\, g}$$

c being taken from Smith's tables.

The available power back of the nozzle is taken from:

$$\text{HP.} = 0.1134\ Q\ H$$

In the electrical horse-power output on the switchboard, correction has been made of 4 HP. used to drive the blower, which was not recorded on the meters.

RESULTS.—Three tests were made: First, a run on a 2-in. tip with bronze needle; second, a run on a 2-in. tip with steel needle, and, third, a single observation on a 2¼-in. tip, with steel needle.

Since the efficiency of the generator is not known below half load the results of the combined efficiency of the wheel and generator are given throughout the whole range. The results are graphically recorded in Fig. 3. Diagram 1 shows the curve of generator efficiency; diagram 2 shows the efficiency of the wheel down to half load for the first run, using the bronze needle; diagram 3 shows the efficiency of the wheel down to half load for the second run, with steel needle; and diagram 4 shows the combined efficiency of the wheel and generator throughout the whole range, with both needles.

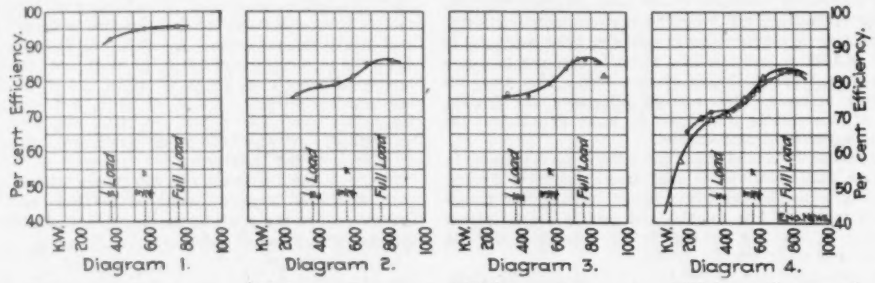

Diagram 1. Efficiency Curve of Generator.

Diagram 2. Efficiency Curve of Water-wheel, 2-in. Nozzle, Bronze Needle.

Diagram 3. Efficiency Curve of Water-wheel, 2-in. Tip, Steel Needle.

Diagram 4. Efficiency Curves of Water-wheel and Generator Combined. Full Line for Bronze Needle; Dotted Line for Steel Needle.

FIG. 3. EFFICIENCIES OF GENERATOR, WHEEL AND BOTH COMBINED.

The difference between the results with bronze and steel needles is due to the very slight difference in curvature and not in any way to the difference in material. The results show the necessity for very careful calcuation to establish the most efficient shapes of needle and tip. When once obtained the efficiency is not only higher when the parts are new, but is retained, also, for a much longer time, just as would be expected, less energy being expended in eddy currents that are an invariable cause of wear.

It is to be regretted that, in taking these measurements, only commercial instruments were available. These, however, were new and in the best possible condition, and there is no reason to believe that the readings are not absolutely correct. It is unfortunate, however, that they could not have been specially calibrated for the work.

SOME METHODS AND COSTS OF CONCRETE MIXING ON THE BUFFALO, N. Y., BREAKWATER.

By Emile Low,* M. Am. Soc. C. E.

In Engineering News of July 2, 1903, Mr. James H. Harlow propounded a number of questions concerning concrete mixing, and asked for information in answer to them. In reply the writer submits some facts and figures relating to the building of a portion of the concrete superstructure on the South Harbor section of the Buffalo, N. Y., breakwater, constructed during the spring of 1902. He will answer the questions categorically as follows:

(1) As to the kind and size of mixers used.

The mixer used on this work was a cube mixer, the dimensions being 5 ft. on a side, having a cubical capacity of 125 cu. ft. It was installed on the deck of a dismantled lake schooner, called the "Tracy J. Bronson." This vessel is 137.3 ft. long, 26.6 ft. beam, and 11.6 ft. deep. The mixer was supported by the usual trestle or frame work, which was located on the forward end of the vessel. It was run by a horizontal engine with a 9 × 12-in. cylinder, located just back of the mixer on the port side. The steam was supplied by a 4 × 10-ft. locomotive boiler, which also furnished the steam for running the two double-drum, double-cylinder engines, which operated the two hoisting derricks used for elevating the concrete materials and mixed concrete. Fig. 1 is a sketch plan of the mixer plant.

The broken stone was brought to the work in canal boats, and the cement, sand and gravel in remodeled dump scows, the decked pockets of which were utilized for the storage of the various ingredients. Referring to the sketch plan, Fig. 1, derrick A hoisted the concrete ingredients to the mixer, and derrick B handled the mixed products in skips (transported on a small car from under the mixer) to the work.

(2) As to the quantity of concrete made per unit of time.

The work in question consisted in the building of ten so-called parapet wall sections. These each consisted of two main walls, the rear and front walls, and two smaller end walls. The average contents of a section was 84.1 cu. yds. There were also 17 parapet deck sections, supported partly by the parapet walls and partly by the confined stone filling. They were about 36 ft. long, 16 ft. wide, and 4 ft. thick, and contained on an average 101.2 cu. yds.

During the building of these sections, an accurate account was kept of the force employed and of the exact time worked, also of the number of batches made, the latter being obtained automatically by an ingenious counter attached to derrick B, whose registry was absolute.

The ten parapet walls sections contained 841 cu. yds., which required 46.2 hours actual work. The number of batches of concrete placed was 783. From these data we obtain 18.2 cu. yds. of concrete made and placed per hour. During the same period of time 17 batches were placed. From this it will be noticed that each batch contained

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a little over 1 cu. yd. of rammed concrete, or, to be exact, 1.07 cu. yds.

The 17 parapet deck sections contained 1,720 cu. yds., which required 88.1 hours' work. The number of batches placed was 1,596. This gives 19.5 cu. yds. per hour made and placed. During the same period of time 18.8 batches were placed, one batch being equal to 1.08 cu. yds. of rammed concrete. It may be stated here that the parapet deck sections contained 1,531 batches of regular concrete, and 129 batches, with the broken stone left out, to be used as a top finish. These latter batches contained but half the quantity of the former.

(3) As to the quality of the concrete made.

The quality of the concrete was first class, as was fully demonstrated by blasting out a section by dynamite, which had been dislodged by a heavy sea. It was found to be thoroughly homogeneous, and compact, and it weighed 152 lbs. per cu. ft., which is the ordinary weight of good sandstone.

(4) As to the detailed cost in days and dollars, of making and placing concrete.

On the work in question, the operations may be treated under three heads: (1) loading materials; (2) mixing materials; and (3) placing mixed materials.

The force employed in loading materials consisted of the following men:

		Price per hour.	Total.
1	assistant foreman	$0.20	$0.20
2	inside cement handlers	.17½	.35
1	outside cement handler	.17½	.17½
3	sand shovelers	.17½	.52½
2	gravel shovelers	.17½	.35
8	broken stone shovelers	.17½	1.40
1	hooker-on	.17½	.17½
18 men.	Total cost per hour		$3.17½

As previously stated, the time occupied in making one parapet wall section, containing 84.1 cu. yds., was 4.62 hours, at a cost of $14.67, or 17.4 cts. per cu. yd.

The work of loading materials may be briefly described as follows: The material scow contained two pockets of sand, one of gravel, and one of cement, the last being roofed over to protect it from the rain. The two inside cement men worked in this house, passing out the cement in lots of six bags, to the outside cement man, who cut the strings, opened the bags and poured the cement into a steel bucket placed in a convenient well. The three sand shovelers were each furnished with a wheelbarrow containing 3.6 cu. ft. Three of these barrows constituted a charge; this material was wheeled in tandem to the charging bucket. The two gravel shovelers were provided with smaller wheelbarrows containing each 2.7 cu. ft.; two of these constituted a charge. A charge, therefore, contained:

6	bags of cement (1⅛ barrels)	5.4 cu. ft.
3	large wheelbarrows of sand	10.8 "
2	small wheelbarrows of gravel	5.4 "
	Total	21.6 cu. ft.

The canal boat contained the unscreened broken limestone. This was loaded by the eight shovelers into another steel bucket, also containing 21.6 cu. ft., which, when filled, was hoisted to the top of the mixer by a derrick. The two buckets thus alternated in rapid succession. The force on the mixer consisted of:

		Price per hour.	Total.
1	dumper on top	$0.17½	$0.17½
1	charger	.17½	.17½
2	car men	.17½	.35
2	enginemen	.32½	.65
4	tag men	.20	.80
1	fireman	.20	.20
11 men.	Total cost per hour		$2.35

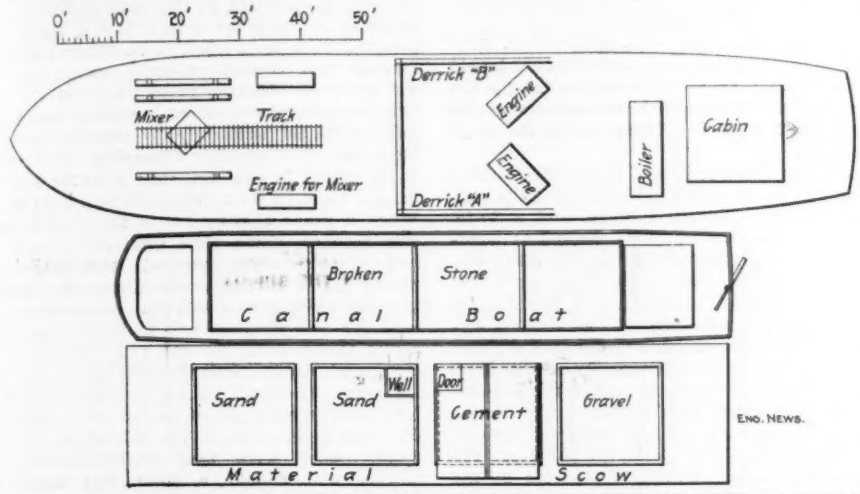


FIG. 1. SKETCH PLAN OF CONCRETE MIXING PLANT FOR SUPERSTRUCTURE OF BUFFALO BREAKWATER.

The cost per section was $10.86, or 12.9 cts. per cu. yd.

The dumper at the top, in addition to the work of dumping the ingredients into the hopper, also attended to the water supply, turning it on and off. The charger put the mixer in operation. The car men unloaded the mixed concrete by opening the mixer door, allowing the contents to fall into a skip resting on a small car, which was run out into the open space, between the mixer and derricks, where one of the latter was hooked on and the batch hoisted to the work. As there were two hoisting derricks, two runners or enginemen were needed. The tag men or swingers swung the booms, one letting the tail ropes pay out and the other letting it wind up, reversing the operation as the boom swung to or from the work. The engine force with the fireman was the largest item of expense on the mixer, in fact it was 70 per cent. of the whole. It might have been barely possible to have handled all operations with one derrick, which would have given only one minute to each of the buckets. The force on the wall or work consisted of:

		Price per hour.	Total.
1	foreman	$0.40	$0.40
1	signalman	.17½	.17½
1	dumper	.17½	.17½
6	shovelers	.20	1.20
4	rammers	.17½	.70
13 men.	Total cost per hour		$2.65

The cost per section was $12.24, or 14.6 cts. per cu. yd.

It will be noticed that the foreman is charged to the wall, when more properly one-half of his time might have been charged to the mixer. However, this does not affect the total cost, which for one parapet wall section is as below:

		Per cu. yd.
(1)	Loading materials	$14.67 or 17.4 cts
(2)	Mixing materials	10.86 " 12.9 "
(3)	Placing mixed materials	12.24 " 14.6 "
	Total	$37.77 or 44.9 cts.

The average time to make one cubic yard of rammed concrete was nearly 3.3 minutes, or .055-hour. Tabulating the various classes of work, we get the following detailed costs:

On loading material:

1	assistant foreman	0.055 hrs.	at 20 cts.	$0.01
2	inside cement men	.110 "	" 17½ "	.02
1	outside cement man	.055 "	" 17½ "	.01
3	sand shovelers	.165 "	" 17½ "	.03
2	gravel shovelers	.110 "	" 17½ "	.02
8	broken stone shovelers	.440 "	" 17½ "	.07
1	hooker-up	.055 "	" 17½ "	.01
18 men.	Cost per cu. yd.			$0.174

On mixer:

1	dumper	0.055 hrs.	at 17½ cts.	$0.01
1	charger	.055 "	" 17½ "	.01
2	car men	.110 "	" 17½ "	.02
2	enginemen	.110 "	" 32½ "	.03
4	tag men	.220 "	" 20 "	.04
1	fireman	.055 "	" 20 "	.01
11 men.	Cost per cu. yd.			$0.129

On wall:

1	foreman	$0.055 hrs.	at 40 cts.	$0.02
1	signalman	.055 "	" 17½ "	.01
1	dumper	.055 "	" 17½ "	.01
6	shovelers	.330 "	" 20 "	.06
4	tampers	.220 "	" 17½ "	.04
13 men.	Cost per cu. yd.			$0.146

FIG. 2. VIEW OF CONCRETE MIXING PLANT FOR BUFFALO BREAKWATER SUPERSTRUCTURE.

In making the parapet deck sections, the force loading materials consisted of two men more, there being four sand shovelers and nine broken stone shovelers. On the mixer there was also an extra man to handle the car. On the wall the force was the same. The average contents of a parapet deck section was 101.2 cu. yds., and on

an average 5.18 hours were consumed in making one.

		Per cu. yd.
(1) Loading materials	$18.26	or 18.0 cts.
(2) Mixing materials	13.08	" 12.9 "
(3) Placing mixed materials	13.73	" 13.6 "
Total	$45.07	or 44.5 cts.

The average time to make one cubic yard of rammed concrete was nearly 3.1 minutes, or .051-hour. Resume:

1 foreman	0.051	hrs. at	40 cts.	$0.02
1 assistant foreman	.051	" "	20 "	.01
2 engineemen	.102	" "	32½"	.03
4 tag men	.204	" "	20 "	.04
1 fireman	.051	" "	20 "	.01
30 laborers	1.536	" "	17½"	.27
6 laborers	.306	" "	20 "	.06
45 men. Cost per cu. yd.				$0.445

(5) As to proportions of cement, sand and stone used.

These were 1 part cement, 1 part gravel, 2 parts sand grit, and 4 parts unscreened broken stone. One bag of cement was assumed to measure 0.9 cu. ft., and was adopted as a unit for measurement, the vessels in which the gravel, sand and unscreened broken stone were measured, being all multiples of a bag of cement. The voids in the sand grit and gravel were 27 per cent. and in the unscreened broken stone 39 per cent.

(6) Whether the mixing of the cement with the crushed stone aggregate without screening does not make a better concrete than the adding of sand after passing the stone through the screens.

This is a question concerning which there is some disagreement among engineers. Conservative ones still call for screened broken stone in their specifications, but I think without reason. There is no doubt in my mind but that the unscreened stone makes a better concrete. The various sized fragments seem to fit together more readily, making undoubtedly a denser mass. So far as the crushed stone sand is concerned, it is a fact that briquettes made from this material show a great tensile strength. The main desiderata in making concrete are: first, to coat each fragment or particle of stone, gravel and sand with cement mortar, and, next, to completely fill all the voids between them. How best to accomplish this, is certainly the business of each particular engineer, who should determine by experiment for himself, and not blindly follow the practices of others, who make concrete by certain methods or rote, because still others have made it that way.

There is certainly no other product about which so many peculiar notions have been held among engineers. I remember when it was considered the best way to make concrete to put down a layer of broken stone and grout the same. In fact the concrete bottom of the eastern compartment of the Hiland Ave. reservoir of the Pittsburg, Pa., water-works was made in this manner. Then we had a number of ways of mixing the various ingredients, making a mortar of cement and sand, and mixing with it the broken stone; also mixing the various ingredients altogether, or in a certain order, and so ad infinitum. After that we had long and tedious controversies about dry and wet mixing, in fact even to-day, engineers are not agreed which is the better mixture.

(7) Many engineers seem to prefer the batch mixing machines, such as the old cubical mixer. Are there any good reasons for this?

(8) What are the reasons for and against batch vs. continuous mixers?

The argument in favor of the old cubical mixer is the more intimate intermingling of the ingredients caused by the constantly shifting position of the mass by reason of the rotation of the cube, hung up at opposite corners. That this is undoubtedly true cannot be gainsaid. The same results are obtained in a greater or less degree by the Ransome, Smith and other mixers.

In this connection it is well to bear in mind that a perfect intermixture can only be obtained where the batches are small, containing less than a cubic yard of aggregates. Where the cubical mixer is used, the general practice is to mix the cement, sand (and gravel) and dump them in one batch into the mixer; this is followed by a batch of broken stone. It will be readily seen that considerable "shaking up" is necessary to form a homogeneous mixture; in fact, it is hardly ever attained. The remedy is to mix all ingredients in smaller quantities. Where the batches are hoisted by derricks, this, of course, entails much extra handling of materials on the part of the contractor, and is objected to on the score of expense. The other alternative is to rectify improper mixing as much as possible after the mixture is dumped on the work, and it usually can be done quite readily, as the concrete must necessarily be shoveled to obtain the requisite depth of layer for tamping.

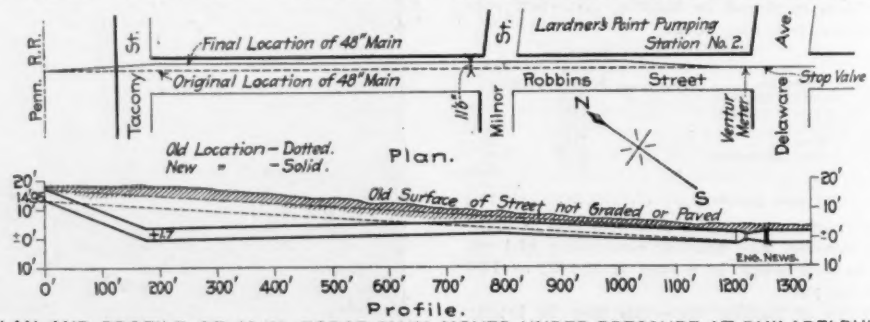
MOVING A 48-IN. FORCE MAIN UNDER PRESSURE, AT PHILADELPHIA.

By Seth M. Van Loan,* Jun. Am. Soc. C. E.

Before proceeding with the main feature herein described it may be well to outline briefly the reasons why the undertaking was necessary, and also show the conditions existing during the progress of work.

Wentz Farm Reservoir, one of the distributing basins of the water-works of Philadelphia, is supplied with water through a 48-in. and a 30-in. main, the pumping station being located at Lardner's Point on the Delaware River, 4½ miles distant from reservoir. The work under operation for the improvement, extension and filtration of the water supply for the city of Philadelphia embodies an enlargement of the Lardner's Point pumping station from a daily capacity of 51,000,000 gallons to 300,000,000 gallons, and a relative extension of the distribution system. The mains leading from the new station are four lines of 60-in. pipe, and are located between the boundaries of the street already occupied by the two mains above mentioned, a condition requiring the removal and relocation of both the 48-in. and the 30-in. pipe. At the present writing the working capacity of Lardner's Point Pumping station amounts to 38,000,000 gallons daily, of which 29,000,000 gallons pass through the 48-in. main, or practically 75% of the supply, this being from the partial service of four pumps maintaining a pressure of 70 lbs. The city authorities naturally objected to a suspension of the main artery of supply to the reservoir, and the only alternative was to remove and relocate the 48-in. main under pressure. The 30-in. line was not considered so important a factor for service and was placed in its new position by disconnecting and relaying, chiefly by unit lengths, in consequence of which no further mention will be made in connection with the smaller pipe.

The original laying length of the 48-in. pipe



PLAN AND PROFILE OF 48-IN. FORCE MAIN MOVED UNDER PRESSURE AT PHILADELPHIA.

was 1,194.45 ft., the limits being a Venturi meter and stop valve at one end and the Pennsylvania Railroad reservation at the other. The limits showed a difference in elevation of practically 15 ft., the course being generally rising.

The new location called for a deflection in alinement of 11 ft. 6 ins., and at each end of the portion of pipe moved 200 ft. were allowed for this change. In order to effect certain connections with the new 60-in. mains a depression of 13 ft. 2 ins. was necessary, the same limit of 200 ft. holding in this case. The plan and profile shown herewith indicate the relative positions of the original and final alinement.

To place the pipe in its new position the actual laying length was found to be 14 ins. longer than in its original location, which indicated the necessity of drawing the joints to that extent. It might appear that 14 ins. distributed over 100 joints would offer no difficulties, providing each joint would perform its respective duty, but the additional length was, in a measure, required at one end, limited, as is mentioned above, to a distance of 200 ft. This required increase in the length of the pipe, taken with the decided opening of the joints required to break down on the established grade, demanded that the utmost care be exercised during the progress of moving.

The method of procedure was to prepare the trench for the final location of main, uncovering the pipe in question at the same operation. Excavation beneath the pipe followed, earth being removed to a level about 2 ft. below the barrel, leaving that section of earth which supported the blocking. Having prepared about 200 ft. in this manner, the work of lowering was started and conducted uniformly by digging under the blocking. The greatest depression was the last to be placed in position, thus allowing any gain in pipe to work up to where it was most needed. When a grade slightly above the final elevation was reached, skids were inserted beneath each length, upon which greased iron straps were placed for a sliding surface, and the work of moving laterally was started. Screw jacks were used for this purpose, one for each pipe, placed about 18 ins. from the bell end. The main was then worked over, following the same plan as in lowering. To guard against excessive pull in any joint, marks were placed on top and on each side of every pipe, close to the bell of its neighbor. Small gages were used continually at these marks, and should a joint pull more than the adjacent ones care was taken to relieve it by a manipulation of the screws. During the forcing of the main along the skids counter braces were in position on the opposite side of the pipe, and, as was necessary, sections were sawed from the bracing to allow for the movement of the main. These braces were found to be of decided value, keeping the sections handled from buckling.

During the lateral moving the pipe revolved on its horizontal axis to a decided extent, in some cases as much as 100°, due undoubtedly to forcing the pipes along the inclined skids.

The lead in many joints was forced out ½-in., and in one case as much as 1 in. These joints were not disturbed, unless water spurted, at which time light calking with a chisel stopped the leak. Several men were kept busy looking after these places, and in some cases extra lead was hammered in the joints. Too much pounding of the joints was not allowed, it taking the life out of the lead.

The entire operation of moving the pipe required a month, and only on one occasion was the main relieved from pressure, this resulting from the discovery of a cracked pipe undoubtedly existing when the main was first laid. Bands were placed about this piece which gave no more trouble. A careful measurement was taken after the pipe had been placed in position, and on account of a slight deviation from original lines and grades the actual increase in laying length was found to be 11 ins., a loss of 3 ins. from what was expected.

A rigid inspection was maintained over the entire length of main, both day and night, during the relocation, and men were placed in sight of one another so as in case of emergency to signal the engineers at the pumping station and to those stationed at the nearest stop valves, the former to shut down the pumps and the latter to relieve

*First Assistant Engineer in charge contract No. 28, Improvement Philadelphia Water Supply, 2203 Bridge St., Frankford, Philadelphia, Pa.

the pipe from back pressure. Had a break occurred enormous damage and probable loss of life would have followed.

Mr. John W. Hill, M. Am. Soc. C. E.,* is Chief Engineer of the Bureau of Filtration. The contractor for the work described was Harmer & Quinn, of Philadelphia.

PAINTING AND MAINTAINING STEEL CARS.*

By J. D. Wright.†

The condition of the metal surface when the coating is applied is, perhaps, more important than the mixture used for its preservation. A metal surface which has been cleaned by a sand blast is, no doubt, in the best possible condition for a prime coating, but from my observations of the methods in vogue in contract shops, I am afraid the question of cleaning steel cars with a sand blast will have to be answered in the negative until the time arrives when protective coatings receive more consideration than they do at the present time, and improvements are made in the methods of sand blasting. However, there is no excuse for applying good material over grease, oil, loose scale, loose rust and dirt which can be easily removed with benzine, scrapers and wire brushes by ordinary methods in a comparatively short time.

All parts which are not accessible after the construction is completed should be coated before being assembled. While the cars are being erected all joints, laps and seams, wherever metal is placed upon metal, should be filled with a suitable heavy mixture of the consistency of soft putty to make these parts acid proof and waterproof. When the construction is completed all accessible parts of the underframing body (both inside and outside) and trucks, should be cleaned properly and entirely covered with a suitable protective coating. Taking the coatings now in general use as a basis, the underframing and all parts of the body should receive at least three coats, except the parts of the inside which come in contact with the coal. These parts and the trucks should receive at least two coats.

There are three ways of applying protective coatings; (1) spreading the material on with a brush; (2) blowing it on with a pneumatic painting machine; (3) the dipping process. The brush is a well-known and reliable tool and in the hands of a good workman it will spread on an even and satisfactory coating. The pneumatic machine is objectionable from the fact that there is more or less moisture in compressed air, which is not a good thing for the steel, and it does not apply the coatings as evenly as the brush. The dipping process is not, to my knowledge, in use for painting steel cars, but it would seem that this method might be used to advantage, and it would carry the material to parts which are inaccessible by the other methods.

The best material for protective coatings is an open question. Cement, red lead, tar, iron oxide, asphalt, graphite and carbon mixtures have their advocates. Some prefer varnish-like coatings, claiming that they are impervious to moisture, while others believe that very elastic oil mixtures will give the best results. Much depends upon the properties of the pigment and vehicle, and the combination formed by their mixture. For instance, a good iron oxide paint might give better results than a poor carbon mixture, and a graphite carrying a percentage of inert material might give better results than a pure graphite paint. Carbon seems to be the most popular pigment at the present time, suspended in a vehicle composed largely of linseed oil which has been treated in order to assist the pigment in making the coating impermeable. Our tests show these mixtures to have considerable merit. After testing all the ordinary mixtures, and a great many preparations offered by manufacturers, we have failed to find a preservative coating which is entirely satisfactory for steel cars. Some improvements, however, have been made and we may look for further advancement in the near future. It is not wise to place too much weight on the performance of a sample of material on a small piece of tin, a small test panel, or even on one car. It is much better to take the average results from an extensive comparative and practical test on a number of cars in actual service. Take, for instance, a lot of 25 cars and coat half of each car with sample No. 1 and the other half with sample No. 2, allowing the two samples to meet in the center of each side.

We now come to the maintenance of steel cars. After they have been coated properly with the best protective coating that can be found, they are placed in service (most of them in the coal trade) and it is interesting to follow their movements for a short time and see the treatment they receive, with a view to finding out why the best coatings do not protect. The hopper cars are run to the mines where most of the coating is soon knocked off the inside parts by the coal as it falls into the cars. While in transit the rain on the coal forms a dilute acid which gets in its work on the metal wherever the coating has been knocked off. When they reach the coal piers to be unloaded they are pounded on the outside with bars and mauls in order to make the coal run; and sometimes in cold weather a natural gas or oil flame is turned on the cars to thaw out the ice. If this is not enough they are run to the steel mills and loaded with red-hot material and the coating is burned off. In short, the treatment they receive makes one ask what is the use of applying a protective coating? At the end of a few months' service the inside parts show few signs of protection and the outsides are covered by rust spots, which have been started by the coating being knocked off in various ways. It is very evident that steel cars cannot be protected perfectly at all times by paint coatings which may be knocked off by abrasion. Nevertheless, they seem to be the best protection against corrosion known at the present time.

To give the metal a reasonable amount of protection by the use of paints, as they are now designed, it will be necessary to repaint the outside parts and underframing about every three years and the inside parts every year, the loose scale and corrosion being removed by the use of scrapers and steel wire brushes before paint is applied. It will, no doubt, pay to coat the inside parts occasionally, but, in my opinion, it will not pay to spend much time on the cleaning, or applying an expensive material. From the results of several tests which we made recently I am inclined to think tar paints, when free from acids, suitable for the interiors of coal-hopper cars.

*Abstracts of two papers read at the annual convention of the Master Car & Locomotive Painters' Association.

†General Foreman of Painters; Baltimore & Ohio R. R., Baltimore, Md.

By W. O. Quest.*

The scale and rust should all be removed before the first painting, whether or not the scale be of the loose or close-adhering kind, and notwithstanding the fact that many interested people hold the opinion that there are no dangers in painting over a new close-adhering scale.

How the scale and rust can be economically removed from the steel car would be a suggestion of interest. All kinds of methods and materials are used, but the expense and grind is too great for muscular force alone, the task calling for machinery manipulation. The small pneumatic chisel rigged hammer tool has been recommended as a thorough scale remover, as is also the compressed air operated sand blast. Our trial of the pneumatic hammer being anything but satisfactory, particularly on account of slowness, we turned our attention to the sand blast, the most practical and effective method of removing mill, scale, rust, dirt and grease from structural iron and steel. The result after the use of the sand blast is a bright, clean metallic surface, a perfect condition for paint adhesion which cannot possibly be secured where even the best of protective paint is applied upon a slag-enameled or a pitted rust-eaten surface.

Properly handled, the sand blast will reach and effectually clean every portion of the steel car's surface otherwise inaccessible to hand cleaning where using the wire brush, steel scraper, chunks of emery, sandstone, etc., usually employed for such purpose at great outlay of time and labor, many difficulties and little effect. The efficiency of the well-appointed sand blast is an assured fact, and as an economy the method is past the experimental stage. There is really nothing remaining for the interested steel car manufacturer (also railway company) to do but to provide efficient and permanent plants to remove all scale from the new structural steel before assembling, also from the steel car to be repainted in repairs.

We have had very good results with home-planned and constructed machines in our McKees Rocks shops. Our experience so far in cleaning old paint, rust and scale from steel cars with the sand blast has been limited to three 100,000-lb. capacity hopper bottom cars. We use a 30-gallon sand capacity portable machine on the work, which is operated with a 100-lb. air pressure, having a free delivery of about 18 cu. ft. per minute. The weather being dry when tests were made, the sand was gathered up and sifted back into the machine and repeatedly used. The company's powerful stationary sand blast, rigged with an air sand-lifting device, with the same generated air force and delivery as mentioned above, will scale off a surface of new plate steel 100 sq. ft. in an hour, if properly handled.

Our practical experience in painting steel cars has been so varied in our endeavor to get something that would stick to the surface that we almost hesitate to pass an opinion on results of the experience. We have painted cars with iron oxide, carbon blacks, graphites, red leads, asphaltums, coal tars and other paints of a similar character. We have both tested and used a number of highly recommended and endorsed paints on steel cars, which proved utterly worthless for the purpose.

The standard makes of iron oxide paints, where mixed to counteract the strong oxidizing properties of the pigment, are, in our estimation, good all-around paints, and where made up to requirements, have given us good, average results as a steel car paint in the past, and we think will give better results in the future, where applied as an elastic mix on the promised all-cleaned steel surface.

Carbon black as a protective coating was applied on the first 150 steel hopper bottom coal cars of 80,000 lbs. capacity received by the P. & L. E. R. R. early in 1897. The last of this lot of cars are now being repainted as they pass through the repair yard. This carbon coating failed to prevent scaling off where applied to slag-covered parts of the surface, but we have found that surface parts free, or but slightly slag coated, still retain an intact, almost perfect protective coating.

Our experience with a number of steel cars experimentally painted with graphite has convinced us that graphite, as a natural carbon pigment where mixed with a first-class binding and wearing vehicle, is almost equal to the manufactured carbon black, as far as regards an elastic protection for a metallic surface. After a number of practical tests we have never observed a single instance where a finely ground, properly mixed graphite paint has failed to show up well as an elastic drying, protective coating. Graphite as a paint pigment, properly mixed, appears to have the power of repelling oxidation to the limit of producing a long-wearing elastic coat. We have also particularly noted that the service-broken graphite coating offers a very strong resistance against further under-corrosion, showing conclusively that if continued elasticity is the life of paint, a good honest graphite paint should be classed as a protector in the painting and maintenance of the steel car.

But with the best methods of painting and maintaining the practice could not be made beneficial if the present abuse of the steel car continues to prevail. To be a metallic structure seemingly invites the quick destruction of the steel car. Being of steel, the car is loaded with heavy hot and cold billets, which are dropped a distance of several feet, in quantities, from a loading bucket operated by a crane; also with red-hot mill slag and cinders, and owing to the fact that the car is of steel the fire of the hot molten load is rarely if ever quenched with water, and as a result will leave a badly warped car side, with the paint thereon totally destroyed. The load of coal, iron ore, slag, cinder, broken stone, gravel, etc., becomes water-bound and frozen up in winter. When this condition prevails in the Pittsburg district the following quick twentieth-century inventions are used: Lines of burning gas jets are placed in the center of the tracks, trained on under car bodies; steam, rigged up in huge box-like buildings; the crowbar, pick, powder and dynamite are used; and, last, but not least, the large hopper wrench is used to strike heavy vibratory blows on the side sheets, making deep-cut abrasions at every blow in the main muscular efforts of starting the loads into the discharging hoppers of the steel car.

A perfect preparatory cleaning with the sand blast when newly built should be followed up with a coat of paint on the same day, if cleaned out of doors. All paint should be a first-class special steel car paint, skilfully applied at the rate of one coat every 24 hours only. Where the steel car continues to receive its present harsh service, treatment, it should be repainted every two years on the outside; also spray-coated with crude petroleum oil on the inside every six months, it being possible that the crude oil applications would reduce the inside accumulations of flaked-up rust.

*Master Car Painter; Pittsburg & Lake Erie R. R., McKees Rocks, Pa.

THE TOTAL MERCHANT SHIPPING OF THE WORLD, according to Lloyd's statistics, amounts to 33,645,000 tons, divided between steam and sailing vessels, as follows:

	Number.	Tonnage.
Steamers	17,761	27,183,000
Sailing vessels	12,182	6,459,000

While the production of very large vessels has greatly increased during the past few years, the great bulk of the world's commerce is still carried in vessels of moderate size. The total number of merchant vessels above 10,000 tons in the world is only 89. The number of vessels above 5,000 tons are shown in the following table:

Flag.	5,000 to 7,000 tons.	7,000 to 10,000 tons.	Over 10,000 tons.
British	366	119	48
German	59	15	26
American	34	7	7
French	30	4	2
Dutch	6	1	4
Russian	10	2	..
Austro-Hungarian	4	1	..
Japanese	16	..	..
Spanish	7	..	..
Danish	..	1	2

It will surprise many to learn that the United States is the second nation of the world in the size of its merchant marine; but the bulk of the tonnage is engaged in the coasting trade and the Great Lakes traffic. The total merchant marine of the leading nations is summarized as follows:

Flag.	Tonnage.
1. British	16,006,374
2. American	3,611,956
3. German	3,283,247
4. Norwegian	1,653,740
5. French	1,622,016
6. Italian	1,180,335
7. Russian	809,648
8. Spanish	764,447
9. Japanese	726,818
10. Swedish	721,116
11. Dutch	658,845
12. Danish	581,247
13. Austro-Hungarian	578,697
14. Greek	378,199
15. Belgian	157,047
16. Brazilian	155,086
17. Turkish	154,494
18. Chilian	103,758
19. Portuguese	101,304
20. Argentine	95,780

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

Many of our readers will recall our illustration and description a year ago of the famous seven-masted schooner "Thos. W. Lawson." We were greatly surprised recently to read in one of our contemporaries devoted to marine matters the statement that this vessel had proved a dismal failure and that her rigging was to be removed and the hull was to be converted into a barge. Inasmuch as we had seen fit to comment very favorably on this vessel at the time of her completion, we deemed it well to make inquiries as to the truth of the statement and the reasons why the vessel had come so far short of the expectations of those who planned her.

The result of our inquiry is, in brief, that the whole story regarding the "Lawson" being a failure, or that she is to be dismantled is a pure fabrication. We can state on the very highest authority that the seven-masted schooner has been a perfect success in every way. She has never been aground save in her first trip, when she struck on Cherry Island flats in the Delaware River, but went off without damage, and she has never had anything expended on her for repairs, the only money spent being for hauling out and cleaning bottom. The "Lawson" draws but 6 ins. more water when fully loaded than the six-masters "Wells" and "Percy" or than a large number of the five-masters, and she finds no trouble in lying at any berth in Boston Harbor where these vessels can lie.

On one trip this summer from Norfolk to Boston she brought 8,115 tons of coal on a draft of 28 ft., and she left Norfolk on Sunday and arrived at Boston on Thursday. From Oct. 21, 1902, when she loaded her first cargo of coal in Philadelphia, to July 10, 1903, she delivered eight cargoes of coal at Boston and earned and paid dividends to her owners amounting to $36,000. Better records could have been made except that for a large part of the time the coal strikes caused long delays in loading cargoes.

Making a reasonable estimate of the cost of the vessel, it seems that the "Lawson" since she began work, has been earning profits for her owners at the rate of probably 20% to 25% per annum on her cost. Of course, a considerable amount must be deducted from this to cover depreciation, risks, etc.; but when all such allowances are made it is clear enough that the big vessel is a most profitable investment.

It may be added that if the "Lawson" were not a success, the big six-master "Douglas," which was launched for the same owners on Aug. 29, and is built on similar lines to the "Lawson," would hardly have been undertaken.

All things considered, therefore, we see no reason to qualify at all our opinion expressed a year ago that the large schooner is a type of vessel which is destined to cut an important figure in the marine transportation of the future.

One thing that impresses the engineer who studies such records of ocean transportation as the above is the large percentage of a vessel's time consumed in taking on and discharging her cargo. This is, of course, more noticeable in the case of vessels making short coasting voyages than in those engaged in foreign trade. For example, in the voyage noted above the "Lawson" was only four days in running from Norfolk to Boston, but it required six working days to discharge the cargo she brought. Even this rate of working required the hoisting of over 1,300 tons of coal per day, a rate of working which would have been deemed impossible only a few years ago.

The value of further reduction in the time of detention of vessels in port, however, is leading to further endeavors to increase the rapidity of handling cargo. An illustration of what is being done in this direction is a remarkable record in hoisting coal from a vessel recently made at the Lincoln Wharf power station of the Boston Elevated Ry. Co. A cargo of run-of-mine bituminous coal was discharged from a vessel at the rate of 320 tons per hour by a single Hunt hoisting tower. At this rate, it will be seen, the time of discharging such a vessel as the "Lawson" could be reduced by probably one-half.

It may be of interest to see what was required to attain this record rate of coal hoisting. In the first place the folding boom from which the hoisting bucket is suspended has an overhang of 40 ft., and is located 90 ft. above the water level. Add to this the depth of the vessel's hold from which the coal is to be lifted and it is evident that a large amount of power must be furnished to hoist over 300 tons per hour to such a height. The ordinary steam plant of 50 to 100 HP. usually installed at coal-handling plants was here replaced by a plant of 300 HP. The hoisting bucket, or "automatic" shovel, is of the well-known type installed by the C. W. Hunt Co., but has a capacity of two tons. In making the record above noted this bucket had to deliver a load every 22 seconds, and each load required a round trip consisting of lowering the shovel from the top of the tower to the coal in the vessel's hold, opening the shovel, filling it with coal, hoisting it a distance of over 100 ft. and emptying its contents into the discharge hopper. The hoisting, it may be noted, was done in six seconds.

Besides the machinery for hoisting, it will be apparent that machinery of similar large capacity had also to be installed for taking care of this stream of coal brought in at the rate of over five tons per minute. This machinery consisted of a coal cracking machine, which broke up any lumps in the coal to dimensions permitting it to be fired on automatic stokers, and automatic carriers which conveyed it to the storage bins.

We hear a great deal of the economy in water carriage attained by the use of the largest class of freight vessels; but this economy is only attainable when means are available for rapidly unloading and loading. If a 10,000-ton vessel has to lie in port three times as long as a 3,000-ton vessel, then the latter may be the more economical carrier, notwithstanding her larger running expenses per ton of cargo. Large ships have paid on the Lakes largely because bulk cargoes are taken on and discharged there with a rapidity unknown anywhere else in the world. Large ships run with economy between the great ports of the world where machinery is available for rapidly moving cargo. For the tramp steamship, however, or the vessel running to ports of minor size where cargo handling facilities are poor, the advantage still appears to lie with the vessel of moderate size.

Whatever differences of opinion there may be as to details, unquestionably the proposition to decrease the width of pavement or macadam on streets of light traffic, advocated or endorsed from time to time by this journal, is meeting with increased favor on the part of both the engineering profession and the general public.

In our correspondence columns this week will be found a letter from Mr. Samuel Whinery strongly favoring narrower paved or macadamized ways, although quite as strongly dissenting from some of the arguments for narrow macadam strips, earth shoulders, and grass strips in place of curbs advanced editorially in this journal, particularly in the issue for Sept. 17. Mr. Whinery prefers slightly wider macadam than we have been advocating and the use of stone curbs placed at the edge of the macadam. He considers curbs necessary and does not believe that curbs 20 ft. apart would necessarily convert, at times, the whole street into a gutter. His arguments on this subject bring up some points worthy of serious consideration. Those points we are not disposed to combat, because we realize that there are two or more sides to this as well as other questions, and because we are far more concerned in certain broad general principles which should govern street improvements than in the details of carrying out those principles. The main point is that the character and width of roadways should vary with the quantity and kind of travel over them and the use made of the abutting property.

We have taken pleasure in calling attention to Mr. Whinery's letter, even though its statements are in some respects opposed to what we have previously published on macadam strips and the omission of stone curbs. We also take pleasure in calling attention to the article, elsewhere in this issue, by Mr. H. K. Bishop, on "The 6-in. Macadamized Streets of Hudson, N. Y." The article affords a practical illustration of the general principles we have been advocating, with the details carried out in general accordance with the ideas expressed by Mr. Whinery. The three views accompanying Mr. Bishop's article show roadways 30, 25 and 20 ft. wide, respectively, macadamized from curb to curb. One of these streets was narrowed from 40 to 30 ft. in width, and instead of a strip of macadam, earth shoulders, and grass slopes at the gutter lines, the full width of 30 ft. was macadamized and stone curbs were set. Stone curbs were also used on the other two streets. If all street improvements were to be judged by a single inflexible rule this work at Hudson might be condemned because the streets were not of so-called standard width, or because they were not paved with brick or asphalt, or because the macadam was not of standard depth; or, going to the other extreme, because the macadam was not narrowed to 16 ft. on the 30 and 25-ft. streets, and to 12 or 14 ft. on the 20-ft. street. But without knowing more of the local conditions, including the sentiments of the people, one is certainly more justified in praising the city and its engineer for the methods adopted than in criticising them for not using earth shoulders and omitting curbs. Nevertheless it can do no harm to call attention to the fact that although narrowing the macadam to 30 ft. reduced its cost by 25%, the reduced cost might have been almost cut in half by macadamizing only a 16-ft. strip, while the 70 cts. or $1 per lin. ft. (according to quality of stone dressing) paid for the curb might have been all or nearly all saved by omitting the curb and sodding to the gutter line.

A commendable step has been taken by the Engineers' Club of Philadelphia. The management of the club has arranged, as noted in our department of Engineering Societies last week, to exchange the privileges of clubhouse and library

with a number of other engineering societies in various parts of the country, the complete list being as follows:

American Institute of Electrical Engineers, 95 Liberty St., New York.
American Institute of Mining Engineers, 99 John St., New York.
American Society of Civil Engineers, 220 West 57th St., New York.
American Society of Mechanical Engineers, 12 West 31st St., New York.
Canadian Society of Civil Engineers, 877 Dorchester St., Montreal, Canada.
Engineers' Club of Brooklyn, 197 Montague St., Brooklyn, N. Y.
Engineers' Club of St. Louis, 709 Pine St., St. Louis, Mo.
Engineers' Club of Scranton, 302 Board of Trade Building, Scranton, Pa.
Engineers' Society of Western Pennsylvania, 410 Penn Ave., Pittsburg, Pa.
Louisiana Engineering Society, 806 Gravier St., New Orleans, La.
New York Railroad Club, Grand Central Station, New York.
Western Society of Engineers, 1739 Monadnock Block, Chicago.

The value of such an interchange of courtesies between engineering societies is obvious enough to the engineer away from home, who is thus enabled through his membership in his home society to find a hospitable welcome at like engineering headquarters in half a dozen other cities. We believe, however, that the benefit accrues to the host quite as much as to the guest, in other words that it is advantageous to the members of the Engineers' Society of Philadelphia, for example, to have their house made use of by engineers from other cities visiting Philadelphia, their right to such courtesy being attested by membership in their home society.

It is doubtless true that the engineering societies generally open their libraries to the free use of any reputable engineer; but comparatively few engineers make use of such privileges or would feel at liberty to do so in the absence of some definite arrangement such as that which is noted above.

It is a pleasure to record such an instance of co-operation between engineering societies as that above noted. It is through such measures that the influence and power of the profession may be most certainly increased.

The appeal of the Naval Civil Engineers for a regrading in rank has been denied by the President. According to a press dispatch from Washington, the President based his decision on the recommendation of Secretary Moody, who is said to have pointed out to the President

> that under existing laws the civil engineer corps has a larger proportion of captains and commanders than the line, and that under the proposed change the proportion of captains and commanders in the civil engineer corps would be much greater than that of any other staff corps, with the exception of chaplains and professors of mathematics. The Secretary adds that rank in the navy "appertains to the line alone, signifying, as it does, military authority and command."

This last sentence has a very familiar sound. It recalls to mind the long battle waged between the line and the staff over the rank of the officers in the Steam Engineering corps—a controversy which was only ended when, under direction of President Roosevelt himself, the officers who commanded below decks were given the authority that was necessary for the efficient performance of their duties.

If rank in the Navy "appertains to the line alone," as Secretary Moody declares, then to be consistent the staff officers should be deprived of their present official titles, notwithstanding the fact that their services are as necessary and their responsibilities as great as those of the line officers. If they are to be given rank, however, they should be given titles suitable to their age, length of service and responsibilities. It is well known that for many years our Navy suffered greatly because of the fact that a man entering the service had to remain a Lieutenant until he was within a few years of retirement. The case is not so bad with the Naval Civil Engineers, fortunately, because their pay does not depend on their rank; yet the prospect of bearing the junior title of Lieutenant until old age is not calculated to attract the ablest men toward the Naval Civil Engineer corps.

THE HEAT TREATMENT OF STEEL.

The British Iron & Steel Institute, as the chief engineering society of the world devoted to the metallurgy of iron and steel manufacture, is rightly giving great prominence to papers on the heat-treatment of steel. Two papers on this subject, read at the recent Barrow meeting of the Institute, were published in our issue of Sept. 24, and we commented at the time on their importance and practical bearing.

It seems to us worth while calling attention to the fact, however, that these English investigators are not after all pioneers; and that the most advanced American engineers have already taken up the heat-treatment of steel in a practical way.

One of the pioneers in this field was Mr. W. A. Sweet, of Syracuse, N. Y., a brother of Prof. John E. Sweet. More than 25 years ago Mr. Sweet manufactured wagon tires at Syracuse, rolling them from old Bessemer rails. He found that the quality of the tire depended very largely on the temperature at which it was finished and that he could get good or bad tires from the same piece of stock by rolling at a high or a low temperature.

Mr. Sweet prepared a paper for the American Institute of Mining Engineers in the late '70s, describing his experience; but it appears never to have been published in the "Transactions." At the Pittsburg meeting in 1879, the late Capt. W. R. Jones quoted Mr. Sweet as saying:

> I have argued for at least six years that Bessemer steel is not well and properly manipulated for any such wear [as that which comes on a steel rail] unless rolled cold enough to set the scale.

Captain Jones, it should be said, quoted Mr. Sweet's statement only to combat it, even though it was supported by such an authority as the late Thomas Egleston, who said at the same meeting:

> The experiments which I have made prove conclusively that the temperatures at which rolling commences and at which the rail leaves the rolls and is laid upon the straightening bed and is allowed to cool have a very decided influence upon its life.

We need hardly say that notwithstanding the skepticism and opposition of the steel makers, the fact that the finishing temperature has a great influence upon the quality of steel has gained wider and wider acceptance, until it is now recognized in the best specifications.

The educational process by which engineers have been brought to understand this matter has been carried on in diverse ways. We may note among them the symposium on the "Physics of Steel," presented at the International Engineering Congress in Chicago in 1893, which was continued during several following years at the meetings of the Mining Engineers. By way of illustration, we may quote as follows from the presidential address of Mr. Henry M. Howe, delivered before the American Institute of Mining Engineers in February, 1894:

> The papers of the present year, which I proposed to group together under the title of the "Physics of Steel," are not the only evidence of the serious study this most important question is receiving. One result of these studies will be a better adaptation of the chemical composition of the metal to the needs of each special use; but a far more important result, I believe, will be a great improvement and extension of the methods of treatment by heat, at least for steel, and possibly for the other metals of construction.
>
> In the hardening and tempering of tools, in the annealing of steel castings, in the chilling and annealing of car-wheels and other cast-iron objects, and in the manufacture of guns, projectiles and armor, we have already extensive and careful if empirical heat-treatment. Even in the manufacture of rails, plates and tires we have been in a measure forced into a kind of heat-treatment; for we may class under this head the regulation of the finishing temperature.
>
> The evidence before us scarcely permits us to doubt that, by proper treatment of steel, we may at will very greatly increase the tenacity, the elastic limit, the ductility, the resistance to wear, or a combination of these properties; and that we can thus fit our metal much more closely to its needs, with the result of greatly improving the objects which it forms, or of greatly lightening them. For this there is good reason to believe that relatively simple and inexpensive methods will suffice. If such methods of greatly increasing the usefulness of steel lie before us, simply awaiting exploration and application, it is certain that they will be explored and applied.
>
> For instance, a ready and safe means, such as we may hope for, of attaining in steel greater resistance to repetition of stress, should permit us to decrease greatly the weight of many structures, especially of those in which weight is objectionable in itself, as it is in the cases of ships, of bridges, and rolling-stock, and in many others. We are promised a great increase in the wearing power of rails through lowering their finishing temperature, and by slightly varying that of steel plates it has been found possible to regulate their physical properties.
>
> . . . . . .
>
> I for one hope to see the day when the use of untreated steel for our important purposes will be regarded as we should now regard the use of cast-iron for rails.

Another notable paper by an American engineer was read in 1894 by Mr. Wm. R. Webster, of Philadelphia, before the Iron & Steel Institute, on the "Relation Between the Chemical Constitution and Physical Properties of Steel." In this paper Mr. Webster called attention to the allowances that have to be made in tensile strength for plates of different thicknesses rolled from the same heat of steel, and due to differences in finishing temperature in rolling. We quote as follows:

> When rolling heavy plates, trouble is often caused by finishing them at too high a temperature, which gives a material with crystalline fracture, poor reduction of area, and poor bends. In order to guard against this and control the finishing temperature, we use very light drafts in rolling, and produce as good results in heavy plates as in light ones. Too much importance cannot be given to the heat treatment of steel.

In the discussion of this paper, Mr. Percy Gilchrist, Member of the Institute's Council, and of world-wide reputation as one of the inventors of the basic Bessemer process of steel manufacture, said:

> The paper was one of the most important ever received by the institute. It drew attention in a scientific manner to a great fact that had been well known by all those observers who had been connected with the production and manipulation of steel, the great fact in question being that within certain limits the chemical composition of a piece of steel was of less importance than its physical state. In plain English that meant that in the case of a plate you could make it hard and in an extreme case as brittle as a carrot by improper heating and rolling, and that you can make another piece from the very same plate almost as tough as leather.

Here is a pretty plain recognition from an official of the Institute of the importance of the leaf from American practice which was given to them by Mr. Webster nearly ten years ago.

It may be objected, however, that in what has preceded the reference has been chiefly to the matter of finishing the work of rolling or forging at a low temperature, whereas Messrs. Stead and Richards propose a heat-treatment pure and simple. In other words their proposition is to extend the processes of hardening and tempering, so familiar in the case of tool steel, to articles of low grade made of ordinary soft steel.

It can be demonstrated, however, that this exact thing has been done in the United States for several years, not experimentally, but on a commercial scale. One example is the well-known Coffin process of treating car axles, in use for many years at the Cambria Iron Works. This process really amounts to hardening and tempering the finished axle. Another and still more direct example is the fact that in one of our largest steel rail mills the practice of applying jets of water to the head of the hot rail—exactly the process described by Messrs. Stead and Richards—has been in use for a considerable time, not in an experimental way on isolated pieces of rail as described by Messrs. Stead and Richards, but in regular routine daily work, turning out rails by thousands of tons.

Another illustration relates to the testing of materials. Engineers are familiar with the quench-bending test for steel, which has been and by many still is generally considered to be the severest possible proof of the quality of the material. It is true that the quench-bending test will reveal the presence of too large a percentage of carbon or other hardness in steel; but it is also true that when steel is rolled so hot that it cools with a coarsely crystalline structure the heating and quenching of the material will reduce the grain and to use the terms adopted by Mr. Stead, increase the percentage of sorbite. Thus it may happen that the quenched piece may be of much better quality than the material it is supposed to represent, and on this account, cold bending tests of material as finished should never be omitted.

At the meeting of the International Testing Congress at Paris in 1900 this important matter was presented in detail in a paper read by Mr. Wm. R. Webster, of Philadelphia. At our request Mr.

Webster has prepared for our columns a paper published elsewhere in this issue in which he sets forth the application of our most recent knowledge of heat-treatment in the drafting of specifications for 18-in. eye-bars for bridge construction.

In conclusion we may say that we have called attention to the work already done on this side of the ocean in the heat-treatment of steel, with no desire to belittle the value of the work which Messrs. Stead and Richards have in hand. The thing of importance is to educate the user and maker of steel both here and abroad to the practical possibilities of correct heat-treatment. While, as we have shown above, they are not working in a wholly new field, their achievements are for that reason all the more certainly of direct practical application; and all the more deserving of careful attention by engineers concerned either with the use or production of steel.

LETTERS TO THE EDITOR.

Relative Corrosion of Iron and Steel Boiler Tubes.

Sir: I note with interest the article in your last issue on iron and steel pipe.

A few years ago the Mutual Boiler Insurance Co. began to insure several hundred small upright boilers, which up to that time had not been insured. Practically none of these were provided with a fusible plug, which is required by Massachusetts laws in all boilers, so that we suggested to the insured that one of the tubes should be removed and an extra heavy tube should be put in its place with fusible plug. The new extra heavy tubes were all steel tubes, while the original tubes were iron. At the end of only a few years the new steel tubes were found pitted and corroded while the iron tubes were as good as ever.

On the other hand we had occasion, a few years ago, on account of failure of deliveries, to use both steel and iron tubes in a large horizontal boiler, and up to date both the steel and iron tubes are lasting equally well.

The boiler in which the steel tubes are doing as well as the iron is run at high pressure with few shutdowns, while the boilers in which the steel tubes gave poor service are mostly heating boilers run at low pressure and laid off during the warm season.

Truly yours, R. S. Hale.

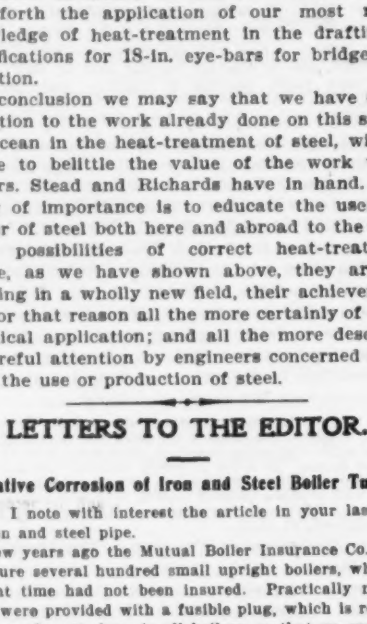
No. 31 Milk St., Boston, Mass., Oct. 2, 1903.

How to Shade Convex and Concave Surfaces.

Sir: Will you kindly publish in the columns of some future issue a sketch showing the difference of shading of concave and convex surfaces, to settle a dispute which has arisen. Respectfully, W. L. Anthony.

Providence, R. I., Aug. 29, 1903.

(The sketch submitted indicates concave and convex sections as well as a V-shaped trough section. In ordinary commercial drafting, surfaces parallel with the plane of vision are not supposed



to be shaded, whereas inclined or curved surfaces should receive either a shading consisting of evenly spaced lines or a "cylinder" shading, which consists of lines of differing thicknesses and graded spaces between them. We have redrawn the sketch and would direct attention to the difference in shading between "concave" and "convex" as well as the "receding" and "projecting" trough shape. Where lack of time prevents the execution of the full shading shown here, a neat compromise may be effected by shading only one-half of the dark side of curved surfaces.—Ed.)

Capacity of Cement Barrels.

Sir: Kindly answer the following through your columns. How much cement packed, loose and shaken will a barrel contain, both natural and Portland, domestic and foreign? I find comparatively little literature on the subject, and also find almost every engineer using a different amount in his calculations. T. C. J. Bailey, Jr.

1208 Lydecker Ave., Washington, D. C.

(In our issue of Oct. 4, 1900, and again in our issue of Dec. 5, 1901, were given the actual contents of barrels of Portland cement of several different brands, domestic and foreign. The capacity of these barrels ranged from 3.12 to 3.5 cu. ft., the American cement barrels being larger. Originally the cement barrel appears to have been a three-bushel barrel (3¾ cu. ft.), and barrels of that size, or even a trifle larger, are used by some manufacturers. We can find no tabulation of capacities of natural cement barrels of different brands. If anything they are a trifle larger than Portland cement barrels. It should be remembered that the cement in a barrel becomes more packed in handling, so that it average about 3% less in bulk than the barrel capacity; but on the other hand it swells about 30% on an average for Portland and as high as 50% for natural cement when dumped out loose. For this reason specifications should always state whether the cement is to be measured loose or packed.—Ed.)

The Efficiency of High-Head Impulse Wheels—A Further Note.

Sir: On page 247 of your issue of Sept. 17 is a letter referring to tests made on two makes of water-wheel at the Redlands plant of the Edison Electric Co., of Los Angeles, in which the following statement occurs:

These tests were conducted by Mr. Samuel Storrow, of the Douglas Building, Los Angeles, and Prof. L. M. Hoskins for the competing wheel, and by Prof. J. N. Le Conte, of the University of California, for the Pelton wheel. The results of the measurements made by these gentlemen on both wheels, as well as the experience of the Edison Electric Co. in the regular service operation of the wheels, has demonstrated beyond a doubt the superior efficiency obtained by the Pelton.

The reader of this statement is likely to infer that the tests referred to were made by methods agreed on by the representatives of both companies, and that those who conducted the tests concurred in the statement made as to the efficiencies of the two wheels. Unless this were true the tests could hardly be regarded as "demonstrating beyond a doubt" anything as to the relative efficiencies of the wheels. As a matter of fact the tests on the Doble wheel were made by Messrs. W. H. Sanders and Samuel Storrow, of Los Angeles, and myself, by methods for which we alone are responsible, and no one of us was present at the test conducted by Professor Le Conte and Mr. Henry on the Pelton wheel, nor were we consulted as to the methods to be employed in that test. I am sure no one of us would wish to be understood as endorsing any statement of efficiency based upon that test.

If my information is correct, the methods and instruments employed in the weir measurements were quite different in the two tests, and until a full description of these is published the public is hardly in a position to judge as to the reliability of the results.

The conditions at this plant are extremely favorable for a comparative test absolutely fair to both wheels. Up to the present time, however, no such test has been made.

L. M. Hoskins.

Palo Alto, Cal., Sept. 30, 1903.

(A note on this matter was printed under "Notes and Queries" in our last issue, Oct. 1, p. 297, to which we refer the reader. We may add here that the author of the passage which Professor Hoskins objects to, Mr. G. J. Henry, Jr., realized its ambiguity after writing the letter and requested us to change the wording so as to eliminate the ambiguity; unfortunately, this request reached our office too late for correcting his original letter before its publication in our issue of Sept. 17.—Ed.)

A Criticism of the Location of a Portion of the Leamington Cut-Off, as Regards Curvature.

Sir: Referring to that portion of the paper on the Leamington Cut-Off in your issue of Sept. 17, which describes the crossing of the Stockton Bar, Mr. Hardesty says that by using some 10° curves a line could have been obtained having "the advantage of easier grades, shortened distance, and easier ground to build through for a distance of nearly 25 miles. By adhering to 4° as a maximum for curvature the line was compelled to ascend a higher summit and "to use a continuous maximum grade for 20 miles, and then to go through the bar with a cut 100 ft. in depth, containing 780,000 cu. yds."

Generally an increase in cost is warranted only when it produces either an increase in comfort and safety, a decrease in running time, or a decrease in operating expenses. The line selected can lay claim to no one of these advantages. It has not the sharp curvature of the original location, but at moderate speed 10 or 12° spiraled curves are perfectly safe and can be traversed without jar or shock. By inserting a short stretch of sharp grade in the approach to the curves a proper speed around them would have been insured independently of the locomotive engineer, and as the sharp curves are at the summit this reduction of velocity (or loss of energy) would be objectionable only in so far as it caused loss of time. This loss of time would not exceed four minutes and would be more than offset by the gain in time in the approach to Stockton Bar by reason of the shorter distance and lighter grade. As to expense, it is indisputable that the lower the summits and the lighter the grade, the less the cost of operation. Therefore, the more expensive line has no advantage in speed or safety and is inferior from an operating point of view; its chief advantage is its appearance upon the map.

This letter is written because I have seen so many cases where the locations secured by wealthy railway companies have been inferior to those they would have adopted had they been forced to economize closely in construction.

Yours respectfully, Edward W. D. Taylor.

666 Cherry St., St. Paul, Minn., Sept. 21, 1903.

(The late A. M. Wellington said in his "Economic Theory of Railway Location:"

It is the peculiarity of curvature that all its disadvantages lie upon the surface, visible to every eye and comprehensible by every mind.

Again and again he condemned the practice of fixing a maximum rate of curvature for railway location. To fix a maximum grade is an entirely different matter since cost of operation depends so largely upon train length. But where sharp curvature does not limit train length, and it usually does not, there is no economic justification in the practice of adopting an inflexible rule as to the maximum curvature.—Ed.)

Some Remarks on the Efficiency of Concrete Mixing Machines.

Sir: Mr. Coleman's contribution on the efficiency of concrete mixing machines in your issue of Aug. 27 should be of great interest. There is another pattern of mixer that he might have included. After personal contact with several of the machines he has discussed, the machine the writer would award first place in Table III., p. 189, is: A box carrying two parallel shafts fitted with paddles moving in opposite directions, both "coming up" in the central line of the box. It is such a mixer as is used for asphalt. This mixer is my winner for the following reasons:

It is a wide-open machine. The water is introduced in as gentle spray as desired by means of a perforated pipe around its rim. The aggregate may be dropped in by the batch at the rate of $t = \sqrt{\frac{2h}{g}}$, and by means of the sliding bottom the discharge is as rapid. The mixing is far ahead of that of cube mixers for speed and more thorough for the reason that masses or lumps are simply impossible.

Mr. Coleman's winner is practically a closed machine. The openings are of no actual value for seeing the performance within the box. It is slow to receive the aggregate and slow to discharge.

My "Table III." would contain items B, D, E and F, and they would receive nearly equal valuations.

From the contractor's standpoint speed is what counts in large operations. Why have a machine running while a batch is shoveled in or put in from the barrows when it may be dropped in—a whole batch in a few seconds? Why wait for the concrete to dribble out at the end when it may be dropped into a wagon or bucket by the batch? The speed of that machine may mean the speed of 100 men. Why put a batch into a closed box and blindly turn it around for a set time, when a wide-open machine allows the foreman or inspector to see the mixing and thus determine the time as the materials vary? Time is everything to the contractor; he is paying for time.

The introduction of water may be either by measured quantities or at the will of the operator in this machine. It is so obviously under control that no further discussion is called for.

From the engineer's standpoint quality of output is the consideration. Being a wide-open machine the inspector's position is an "easy job." He does not have to wait to have the batch dumped. He sees what goes in and

sees it mixed—he need not worry about what comes out. Too many inspectors watch the wrong end of a plant.

Mr. Coleman covered many machines. Here is another. Who has another? Let's have them all!

Edw. Cunningham.

How Tight Joints in Vitrified Pipe Were Secured at Atlantic City, N. J.

Sir: Referring to the article by Mr. J. N. Hazlehurst on the "Infiltration of Ground Water into Sewers," in your issue of Aug. 27, and what he there says on leakage through pipe joints, it may be of interest to mention a line of vitrified pipe recently laid by this department for conveying the discharge from several artesian wells to a collecting basin. The line consisted of 150 ft. each of 8, 10 and 12-in. pipe, 600 ft. of 15-in. and 162 ft. of 18-in. pipe.

The trench was shallow, cuts varying from a few inches to about 5 ft. in depth. The soil was generally sandy, but much of it was wet and swampy. The fall in about 1,212 ft. was 3.3 ft.

When completed all openings were plugged and the main filled with water. A number of small leaks developed, which were recalked where necessary. Several lengths of the 18-in. pipe were found to have fine hair cracks, in every case near the top. As the pipe was carefully inspected before lowering into the trench these were believed to have been caused by careless handling. To avoid delay in replacing these lengths, concrete saddles 4 ins. thick, extending from bell to bell, were built, each of them extending to the bottom of the trench, and the latter backfilled to the top of pipe.

Before covering the upper 450 ft. (which had been subjected to the least pressure), the entire main was filled with water to 2 ft. above the top of pipe at the upper end, giving a head of from 2.0 to 6.8 ft., at the various joints. This caused two leaks on the 15-in. size., but on the upper 450 ft., which was entirely exposed, not a drop of water was observed coming from the pipe, although there was a slight sweating at a few of the joints. From previous experience in similar work these results are believed to be rather unusual and were due to the kind of joint and to the painstaking work of the contractors, the Currie Co., of this city.

As to the joints, the specifications read:

> Joints shall be carefully made, to exclude all leakage, of a stiff paste formed of fresh Rosendale cement of an approved brand thoroughly kneaded into North Carolina pitch pine tar until forming a homogeneous mixture. The joint room shall be completely filled with the paste, which shall be beveled off on the outside.

The joint made in this way appears well suited for work in a wet trench, where infiltration is to be avoided and where settlement is liable to occur. To avoid undue settlement, however, the pipe was laid on 10-in. boards in wet ground and much of this was further supported by short piles of plank. To counteract the tendency of the paste to flow under heat and pressure when first placed, the spigot end in large sizes should be supported inside the bell by blocking, or a hemp gasket may be first driven. Rosendale is believed to be preferable to Portland cement for this kind of joint, but in several cases where leaks were found upon a preliminary test, the joint was reinforced by a rich Portland cement mortar bevel on the outside.

The work was done under the supervision of Mr. E. E. Lanpher, C. E., Assistant Engineer.

Yours truly, Kenneth Allen,
Engineer and Superintendent, Water Department.
Atlantic City, N. J., Sept. 21, 1903.

(We are sure that this contribution to the discussion of securing tight joints in vitrified pipe, used in either water-works or sewerage systems, will be welcomed by many of our readers, and we trust that others will add to the valuable information given by Messrs. Hazlehurst and Allen. —Ed.)

The Use of a Follower or Cap in Pile Driving.

Sir: In commenting upon the article in your issue of Sept. 17, "Is the Use of an Iron Follower or Cap on Piles to be Recommended?" I would say that in driving oak piles even with a ring they are often split. I have seen ringed piles driven that did not show a crack until the ring was removed when they were found to be badly split.

In driving white oak piles into sand and gravel at this place, to a penetration of from 40 to 45 ft., using a 2,500-lb hammer and dropping it 20 ft, we rarely drove more than two or three piles without breaking the 1 × 3-in. ring. The ring was replaced by a follower and we had no more trouble. The follower or cap will require a little heavier hammer or a little more driving if hard wood piles are being driven. It is the other way if soft wood is being driven on account of broomage. The weight of the cap is of no advantage. One considerable gain, however, is that it renders unnecessary the employment of three or four men to hold the pile in place while it is being driven. In difficult driving it is very hard work sometimes to keep a pile in place without the cap, and it is often necessary to stop driving, get lines on the pile and heave it into position with block and tackle.

In this connection I would like to ask where I may find information in regard to the relative efficiency of a drop hammer and a steam hammer. What is the bearing power of a pile driven with a steam hammer?

Very respectfully, T. Warren Allen,
Res. Engr. Pittsburg, Toledo & Western R. R. Co.
Mingo Junction, O., Sept. 21, 1903.

(There is one feature about the use of a cap or bonnet that makes it objectionable where piles vary much in diameter at the butt, namely, that the cap is usually designed to fit a 12 or 14-in. pile, so that oak piles with a larger butt require considerable trimming to fit the cap. Where the driving is very hard this objection, however, is not of great weight. The advantage that a follower possesses by virtue of holding a pile in line, and so dispensing with three or four men, is often more apparent than real. A pile driving crew must usually be large enough to handle the piles, caps, etc., and the men so employed would in most cases be idle during the driving unless they were busy about the driver. But where their services can be better rendered on other work than "steering the pile," it is perfectly practicable to hold the pile in the leaders with yokes, wedges, and the like. Where the driving is easy it may not pay to bother with such devices, but in that case the men are engaged in actually steering the pile only a small fraction of the day.

Regarding the relative efficiency of drop and steam hammers very little exists in print. An editorial discussion of this subject, in which some data are given, will be found in our issue of July 2.

The Engineering News formula for the safe load of piles driven with a steam hammer is:

$$L = \frac{2Wh}{S+0.1}$$

L = safe load in tons.
W = weight of hammer in tons.
h = fall of hammer in feet.
S = set or penetration of pile under last blow in inches, the head of the pile being sound.

There is a lack of experimental data on which to base a closer estimate.—Ed.)

Narrow Paved Roadways on Village and Residence Streets.

Sir: I think you are doing an important service to the profession and to the public, by promoting discussion of the subject of narrow paved roadways for many city and village streets. To pave streets a regulation width, regardless of the quantity of travel to be accommodated, is one of the "ruts" that it seems most difficult to get people out of, though the cost of following it amounts to hundreds of thousands of dollars every year.

Without here discussing the general subject, I wish to challenge some of the statements made in the editorial upon this topic in your issue of Sept. 17.

Your assertion that, "To narrow the distance between curbs to 20 ft., means virtually to make a gutter of the whole roadway wherever the street drains any considerable area," will not, I am sure, be accepted without criticism by those who have for years studied the subject and advocated narrow paved roadways. To begin with, your proposition is novel, since it has not heretofore been thought necessary to design pavements with regard to their efficiency as storm-water sewers, or to make drainage area and discharge capacity factors in computing their width. But even if we are to introduce these elements into the problem, it must be admitted that width is not the only dimension available in designing even sewers. The possibility of increasing the capacity, as a sewer, of a narrow paved roadway, by raising the curbs a few inches in height must not be overlooked. If, however, the width of the channel is to be so increased that there will never be sufficient depth of water in the gutters to wet the feet of pedestrians, we would have some very wide pavements. But admitting for the moment that in some cases the quantity of storm-water to be taken care of may make wide pavements necessary, it may be confidently stated that these cases are so few as to be exceptional, and their existance is no valid argument against the general proposition, that the width of roadways (above a certain minimum) should be determined by the quantity of travel to be provided for.

The capacity of a street gutter is determined, other things being equal, by the product of its width and its depth. If large capacity as a storm-water sewer is desirable, in any case, the depth of the gutter can be increased by giving additional crown to the pavement, and if necessary, increasing the height of the curbs. It is true there is a popular prejudice against high crowns on pavements, but when we call this a prejudice we state its true character. That is another story, however, which I will dismiss with the statement that one of the best and most satisfactory asphalt pavements in existance, constructed in 1888, is 36 ft. between curbs, and has a crown of from 14 ins. to 16 ins. A crown of 6 ins.—the common one for pavements 36 to 40 ft. wide—is not seriously objectionable when applied to a pavement 20 ft. wide. And with such a crown the capacities of the gutters in the two cases, for equal widths of gutter-stream, is in favor of the narrower pavement. Any greater depth of gutter would be seriously objectionable at cross streets, unless gutter bridges were used. In streets where storm-water drainage must be taken care of in the gutters, people must, during rain storms, cross them, whether narrow or wide, at the peril of wet feet. Even if the paved street becomes a canal, people in residential districts, where narrow pavements are more frequently justified, do not usually venture upon the street during torrential rain storms. I think, therefore, you must look up a better argument against narrow paved roadways than this.

Your other argument, that people object to setting out the curbs, is equally untenable. My experience has been that the objection is not to moving the curbs outward, but to the narrow roadway that results; and this is, in turn, nothing more than the inclination to do things as our fathers did them, and because the innovation violates "the good old way." Engineers have found it necessary to combat this species of argument at every step of progress, and why should they balk at this particular ditch of the enemy?

Nor can I agree with you that curbs along streets are unnecessary. The gutter is the receptacle of most of the filth that accumulates on streets, and it is important that it shall be cleanable with the greatest facility and thoroughness. A grassy margin on one side of the gutter not only catches and holds the street filth, but renders proper cleaning difficult or impossible. It is true that a paved gutter, suitably shaped, may be substituted for the curb, but if this is properly constructed it will be quite as expensive as the curb, will occupy more space, and will not be aesthetically so satisfactory.

Yours very truly, S. Whinery.
95-97 Liberty St., New York, Sept. 21, 1903.

Infiltration of Ground Water into Sewers.

Sir: In your issue of Aug. 27, 1903, is an editorial note concerning an article in the same issue, written by Mr. J. N. Hazelhurst on "Infiltration of Ground Water into Sewers." Greatly interested and somewhat experienced in the ground-water question in general, I beg for permission in your pages for the following:

It seems to be almost an axiom in the United states that sewers should be laid at as small a depth as possible in the ground water, which latter should be prevented from entering the pipes. This is surprising to me, because the sanitary efficiency would be far better, were the ground waters drained to the level of the sewers.

In most cases where the writer has designed new sewer systems, complete investigations have been made as to the direction and capacity of the underground water stream; exactly the same as when procuring underground water for water supplies. And it is only after establishing these facts that an opinion can be formed whether the ground water ought to be carried off by the sewers or not. In the first case, *the most usual one*, the ground should be drained by special pipes and wells; these being constructed previous to the final sewer system in such a way that the ground-water level is sunk for a while under the bottom of the pipe trench, after which the pipe-laying can be executed in dry ground. After completing the sewer construction access to the sewer system could be made for the ground waters, or these carried off in special pipes as before.

In nine cases out of ten the capacity of the underground current is so small compared with the sewage, not to speak of the rain water, for which the combined systems are calculated, that the dimensions of the pipes will need only an insignificant increase. The added cost, necessitated by this increase, is small in comparison with the expenses for constructing the pipe line in water-soaked ground. And even when the sewage has to be elevated by pumping, the additional cost for ground-water pumping is very often smaller than the interest on that extra cost which would follow the pipe-laying, if the trench had to be protected from ground water.

The underground stream is also of importance as a never-failing flush tank.

In constructing American sewer systems millions of dollars have been drowned in unsuitable trench work in water-filled sand, where the ground water ought to have been sunk under the bottom of the pipe trenches before beginning actual work, thus making the ground dry, coherent and easily worked.

It is therefore desirable, from an economical as well as from a sanitary point of view, that the sewers should be designed for sinking the level of the ground water.

Yours respectfully, J. Gustav Richert
Professor at the Polytechnical University of Stockholm.
Stockholm, Sweden, Sept. 18, 1903.

(The infiltration problem in America relates almost if not quite wholly to vitrified pipe sewers on

the separate plan; and to sewers which, for one reason or another, it is not considered desirable to utilize as sub-surface water drains. It is not uncommon, however, to provide special sub-drains, or underdrains, both to facilitate sewer construction in wet ground and to effect a permanent lowering of the ground-water level. The ultimate disposal of sewage without creating a nuisance is becoming more and more difficult, necessitating (1) long outfalls, or (2) purification plants or (3) and less frequently pumping works. Sometimes a combination of two of these, and rarely of three, is necessary. Any one of the three conditions alone is sufficient to make it highly desirable to prevent unnecessary additions to the sewage proper. Where lowering the ground water for sanitary or other reasons becomes desirable it is frequently possible to effect it by underdrains discharging into natural water courses. Of course, conditions may be such, in some cities or districts, as to make advisable common channels for conveying both domestic sewage and ground water. Finally, where sewers on the combined system are used the admission of ground water to the sewer generally makes only an insignificant addition to the total volume, but with the separate system American experience shows that the free admission of ground water may cause serious embarrassment unless material increase in the size of the pipe sewers is made to that very end and the problem of ultimate disposal is simple.—Ed.)

Formulas for Concrete-Steel Beams.

Sir: All of the formulas for concrete-steel beams in use are quite complicated in their application. The writer presents the following as a close approximation for practice.

In the issues of the Engineering News for Feb. 27, 1902, and July 17, 1902, the following formulas were given by Professor Hatt:

$$M = bh^2\left[\frac{5cx^2}{12} + pf(u-x)\right] \qquad (1)$$

$$\frac{2}{3}cx = pf \qquad (2)$$

$$\text{and } P\frac{E_s}{E_c}(u-x) = \frac{2x^2}{3} \qquad (3)$$

The reader is referred to these articles for the meaning of the terms in these formulas, and the assumptions underlying them. It is the purpose to simplify them. In practical applications an affected quadratic is always a nuisance.

(1) can be simplified thus:

$$M = bh^2\left[\frac{5cx^2}{12} + pfu - \frac{2cx^2}{3}\right] \quad \text{by (2)}$$

$$= bh^2\left[pfu - \frac{cx^2}{4}\right]$$

$$= bh^2\left[pfu - \frac{3}{8}pfx\right] \quad \text{by (2)}$$

$$= bh^2\,pf\left(u - \frac{3x}{8}\right) \qquad (4)$$

(3) can be simplified by solving for x, thus:

$$p\frac{E_s}{E_c}(u-x) = \frac{2x^2}{3}$$

$$x^2 + \frac{3pE_s}{2E_c}x + \frac{9p^2E_s^2}{16E_c^2} = \frac{3pE_su}{2E_c} + \frac{9p^2E_s^2}{16E_c^2}$$

or very closely,

$$x^2 + \frac{3p\,E_s\,x}{2E_c} + \frac{9p^2\,E_s^2}{16E_c^2} = \frac{3p\,E_su}{2E_c}$$

$$x + \frac{3p\,E_s}{4E_c} = \sqrt{\frac{3p\,E_su}{2E_c}}$$

$$x = \sqrt{\frac{3p\,E_su}{2E_c}} - \frac{3p\,E_s}{4E_c} \qquad (5)$$

In these formulas the tension of the concrete is neglected. If this is considered, a close approximation for M in (4) is,

$$M = bh^2\,pf\left(u - \frac{3x}{8}\right) + \frac{tbh^2}{5}. \qquad (6)$$

In this it is assumed that the neutral axis is at a distance of 0.4 h below the compression flange, and that the curve of stresses is a straight line. Of course, the position of the neutral axis varies, but this is close enough for the purpose of including the tension in the ultimate moment.

For the purposes of designing, a concrete beam fails as soon as a crack appears in the tension flange. The constants as determined by Professor Hatt are

$$C = 1500,\ \frac{E_s}{E_c} = 7.5$$

and t = 300. We will assume u = 1. This is the same as considering all of the metal concentrated on the tension face. Of course it is practically impossible to so build a beam, but we can so figure it, and then add 2 to 4 ins. of concrete to the depth of the beam. The height h in figuring should not include this extra concrete, but only include the metal.

Putting in the above constants our formulas become:

$$x = 3.35\sqrt{p} - 5.62p \qquad (5)$$

$$f = \frac{3350}{\sqrt{p}} - 5620 \qquad (2)$$

$$M = bh^2pf\left[1 - \frac{3x}{8}\right] + 60bh^2 \qquad (6)$$

In the above, p = the ratio of the steel area to the concrete area, and varies between $^1/_{75}$ and $^1/_{100}$ generally. Assume $p = {}^1/_{100}$, then $M = 310\,b\,h^2$.

To determine M for any other value of p, we write

$$M = bh^2(310 + 1.2r) \text{ for } d < 100 \text{ in } \frac{1}{d}$$

$$M = bh^2(310 - 1.2r) \text{ for } d > 100 \text{ in } \frac{1}{d} \qquad (7)$$

Here $p = \frac{1}{d}$, and r = the numerical difference between 100 and d

This was gotten by assuming different values of p and noting the corresponding variation in the coefficient of $b\,h^2$ in the value of M. It will be found that the successive differences are practically constant.

Formulas (7) give the ultimate moment for a beam having constants as given in the articles referred to. Of course, slightly different formulas would be obtained for concrete having a different composition. But in doing preliminary designing it is seldom possible to tell before hand just what kind of concrete will be used, and these formulas should give a close approximation for average stone concrete.

It is to be remembered that M is the ultimate moment for cracking in the tension flange, and a factor of safety must be used in applying (7). It is thus seen that by simple algebraic processes, formulas (1) and (2) are very much simplified in their new form as in (4) and (5). By introducing the experimental constants they are made quite simple.

A valuable field is open for some one to determine the working numerical coefficients for concrete of various proportions. The draftsman before his desk, however, does not want a formula dressed like Kutter's hydraulic formula, or like some of the pile driving formulas of the past.

B. R. Leffler.

17 Olive Place, Cleveland, O., Sept. 13, 1903.

A Further Comparison of Eye-Bars Made by Forging With Those Made by Cutting From Rolled Plates.

Sir: When handing you my letter (published in Engineering News of Sept. 17) referring to the dimensions of eye-bars in the Budapest bridge, and to the difference in quality between forged eye-bars and machined plate-links, I called your attention particularly to the latter, basing my statements and opinion on a very extended experience in testing materials, especially eye-bars.

As you have seen fit to question the reliability of my statements in a foot-note to my letter, I now wish to lay before you and your readers facts and figures which will prove my statements to be correct.

Referring to my tests of eye-bars, I must preface the record of figures by the statement that the testing machines on which the small sample bars were tested had been calibrated by myself by dead weight up to the maximum loads used in these tests. More than this, the large testing machine on which full size eye-bars were tested was calibrated to its capacity by making comparative elastic tests between it and the Emery machine at Watertown Arsenal, using a standard bar more than 25 ft. long. All of these calibration tests are on record.

As it is not convenient for me at the present time to give an extended copy of records of tests, I will refer you for wide plate tests to "Report of Tests of Metals," Document 54, H. R., 54th Congress, 1st Session; pp. 283-289.

Unfortunately these tests do not give determination of elongation, nor did they develop the full strength of the plates, as failure occurred in rivet holes, one of which is always the origin of failure. The tests do show, however, the uniformly high resistance of full-size plates, almost equal to that of the small test specimen.

Results of Tests.

	Tenacity, lbs.	Elongation
Sample test pieces...	70,000 to 75,000	18 to 22% in 8 ins.*
Full-size eye-bars.†..	52,000 " 58,800	12 " 15% " 240 "
Sample test piece..	68,700	22%, 4", or 18.5%, 8"

	Tenacity.		Tenacity.
Test No.	7299...63,920 lbs.	Test No.	7304...62,180 lbs.
" "	7300...60,000 "	" "	7305...62,740 "
" "	7303...62,400 "		

*These two, 70,000-lb. open-hearth steel.

†7 × 1 in.

It must be remembered that the strength of a test piece 4 ins. long is very apt to be higher than that of the 8-in. standard, because of effect of shoulders, especially when as large as shown in the report.

Now, links cut from plates would show a higher resistance than these riveted joint plates, which in spite of the injurious effect of the rivet holes showed the remarkable uniformity and high resistance of plates from 15 to 24 ins. wide and as thin as 7-16 to ½-in. Thicker plates are known to be more uniform in strength because of the lesser liability of effect of temperature changes during rolling.

If I were able to present tests of links cut from plates the results would be much more striking. These riveted joint tests are proper as a basis for above comparison because all of the plates broke outside of the riveted joints.

Now a few words about the cost of making plate links which you consider "to be expensive and wasteful." The actual cost of the entire metal towers and superstructure of the Budapest bridge, about 1,675 ft. long, was $2,010,000.

The actual time of milling each single bar in the plate link chains of the Budapest bridge, was 615 mins. Therefore, the actual cost of milling and boring each bar would be in this country, with machinists wages at 20 cts. per hour, equal to about $2.05 for wages alone.

Will any American engineer consider $2.05 an expensive or wasteful matter in finishing an eye-bar from 15 to 19 ins. wide, by ¾ to 1 in. thick and about 35 ft. long?

It must be borne in mind that the above figures are taken from official reports of cost of manufacture, as published in the "Reports of the Testing Materials Congress," at Paris in 1900.

Trusting that you will find space to publish this valuable information for American engineers, I am,

Very respectfully, Gus. C. Henning.

275 Water St., New York City, Sept. 27, 1903.

(Our correspondent undertakes a very large task in attempting to indict American practice in the use of forged eye-bars in bridge construction; and to prove that the way to make eye-bars is to cut them out of a flat plate. He offers as proof evidence that such a plate subjected to stress with riveted connections showed a strength comparable with that deduced from a test specimen. But this sheds no light on the behavior of an eye-bar actually made from such a plate and strained to the breaking point. Neither does it reveal any reason why the use of forged eye-bars should be abandoned.

At the risk of threshing over old straw, we venture to point out that rolled plates are well known to be weaker transversely than longitudinally, and hence eye-bars cut out of such plate have a tendency to split which has to be counteracted by leaving considerably more surplus metal at the back of the head than is the practice with American forged bars. Another defect of the eye-bar cut from a plate is that it is too thin in proportion to its width and when heavily strained the heads tend to dish. When this occurs of course the load is not uniformly distributed through the section. If any of our readers are inclined to favor the plate eye-bar idea, we suggest experiments with model eye-bars cut from paper or cardboard or tin plate.

Our correspondent also attempts to defend the plate eye-bar on the score of economy. His figures for the labor cost of milling the eye-bars on the Budapest Bridge, with wages at $2 per day of 10 hours are all very well; but that is only a small item. The first cost of the machines used for milling the eye-bars on that bridge was $90,000, or over $20 per ton of eye-bars used; and in the cutting of the eye-bars from the plates, about 45% of the plate had to be discarded.

As for the forged eye-bar, made under modern methods, under up-to-date specifications and inspection, we are inclined to think that it needs no defence. In fact we think it safe to say that there is no part of the typical American bridge truss in which the engineer reposes greater confidence than the eye-bar tension members; and this confidence is justified by the behavior of thousands and tens of thousands of such bridges in actual use for the past half century.—Ed.)

Hydrated Lime.

Sir: We have recently had the pleasure of reading in your issue of Aug. 27 an article on the manufacture and properties of hydrate of lime, by Mr. S. Y. Brigham. We are very glad indeed to see such an article come out by a disinterested party, and we feel there is enough of value in the subject of hydrated lime to admit general discussion. Most of the matter printed heretofore on this subject in the trade journals has been based on information furnished directly by the manufacturers of the product, and is, therefore, open to the natural criticism of coming from an interested party.

We desire to take some exceptions to the statements and data presented by Mr. Brigham, and in an entirely friendly spirit, as our principal motive is to determine positively the facts of the case, and to have them brought to the

attention of the best class of contractors, etc., who, we think, will profit even more by the use of this comparatively new product than the manufacturers themselves.

To assist in bringing hydrated lime to the front, we recently had made by Booth, Garrett & Blair an extensive series of tests, taking different proportions of our "Limoid" (Cedar Hollow hydrated lime) and Portland cement. These tests were published quite generally a short time ago, and I believe your own paper made some reference to same. Discussing the difference betweeen results of Booth, Garrett & Blair, and those of Mr. Brigham, we find the following points:

Mr. Brigham's tests indicate that aging for 14 days decreases the strength. Our tests do not show this at all. The only apparent difference between the two tests is, that Mr. Brigham employed parts of one to three, whereas we employed parts of one to two, in order to make direct comparison between Rosendale cement tests and hydrated lime-Portland cement tests, but owing to the bulkiness of the hydrated product, there should have been no dangerous proportions of voids in Mr. Brigham's sand mixtures to have caused his decreasing tensile results after 14 days.

There is, however, another point which might explain the decrease after 14 days, and it is a question we have been endeavoring to bring out in all matter on the subject, i. e., that many of the manufacturers cannot, and do not thoroughly hydrate the quick lime.

We can positively prove this point to any who may be interested in further investigating this question. As a result of such incomplete hydration, quick lime is found in the product, and this quick lime very frequently lies dormant for some time before beginning to slack. The result is a gradual weakening and possibly disintegration.

The same action is frequently found in plastering with certain limes, that in many cases to our knowledge through incomplete initial slacking and screening, will after many months start the so-called popping or pitting on the wall. This result may not be noticed in some cases for six or eight months after the lime is used.

Mr. Brigham does not say what make of hydrated lime he used in his tests, and while we do not wish to cast any reflection on the product of any other manufacturer, yet it appears that Mr. Brigham's work indicates something in the nature of quick lime in the hydrate that he used.

This is further indicated by what we consider an unnaturally high result in 14 days. Such results are also obtained in Portland cement testing, when the cement contains small percentages of free or quick lime. Portland cement testers are familiar with such initial quick setting and subsequent disintegration.

We consider the result obtained by Booth, Garrett & Blair showing, with one exception, uniform increases in seven days, 28 days and three months' tests, to be far more indicative of results that should be expected in the use of such mixtures, when the hydrated product is thoroughly treated and cured.

There is another phase of Mr. Brigham's article, which does not seem to conform with the results obtained in the East. He states that magnesia lime will not carry as much sand as the high carbonate or fat limes. This has not been our experience in the East, and we had no reason to make our tests indicate more in the interest of one lime than the other, as we are interested in the manufacture of both high carbonate and magnesia limes. We have made many tests comparing the high carbonate limes of both Eastern Pennsylvania and West Virginia, with the dolomite or magnesia limes coming from the Chester Valley District of Eastern Pennsylvania, and our general results are that, whereas the dolomite lump lime will take up by weight about 25% less water than the high carbonates, and make that much less paste, yet when it comes to adding the sand for any of the purposes that a mortar is used, the dolomite lime will carry over 50% more sand than the rich lime, in order to make a mortar of as nearly the same consistency and working conditions and strength as the average mason is able to judge his mixture. Therefore, we have always considered that a pound of Eastern Pennsylvania dolomite lime will make about 25% more mortar than a pound of the high carbonate limes above referred to. In making these tests we have always used our Cedar Hollow lump lime as a sample of dolomite lime for comparison with the high carbonate limes above referred to.

The magnesia limes of the Chester Valley District are a shade or two darker than the high carbonates, and do not work so freely under the trowel as do the high carbonates. The reverse seems to be the case in the Middle West, and what difference this might have made between Mr. Brigham's results and ours, in his tests of hydrate-cement mixture, we are unable to judge.

Mr. Brigham states that the magnesium-oxide left on slacking the lime has no sand carrying capacity. His own results appear to contradict this statement, as his tests show 50 lbs. tensile strength for the high carbonate, as against 90 lbs. tensile strength for the magnesia, at the end of about three weeks. This certainly indicates that the magnesium-oxide has strong cementing properties, and recent tests that we have made using magnesium-oxide separately in combination with other materials, show that magnesium-oxide has very strong cementing properties entirely separate and independent from its combination or association with calcium.

In Portland cement the stronger the neat material is, the greater is its sand carrying capacity for a given ultimate strength, so long as you do not overstep the law providing for filling the voids. We cannot, therefore, see why the magnesium present in dolomite limes should not materially help in the sand carrying capacity, in the light of such knowledge as we have on the subject as stated above. Why the magnesia limes of Ohio should apparently indicate the reverse, when their chemical analysis is almost identical with the Eastern Pennsylvania limes, we cannot say, but we certainly trust that more thorough tests will be made to settle some of these points.

Aside from the possibility of error in testing, there is only one other explanation that presents itself to our minds at present, and that is, that the physical condition of the magnesia limes of the West and East may be materially different, and offset results that might be expected from materials of the same chemical analysis. There is some indication that the physical condition between the two limes might cause the results stated above.

We feel called upon to make some of the statements given above in view of the fact that the article as published by Mr. Brigham, does not do justice to the dolomite limes, at least to those in the East. Trusting that your columns may be the means of clearing up some of these points, as we are very anxious to be set right on whatever points we may be in error, we beg to remain,

Very truly yours, Charles Warner Company.
By Chas. Warner.

Wilmington, Del., Sept. 22, 1903.

Notes and Queries.

Mr. F. W. O'Neil, Chief Engineer of the Champion Copper Co., has sent us some revised figures as to the consumption of water by the stamp mills, correcting his paper on the Intake Tunnel at the Champion Mill, as printed in our issue of Oct. 1. The corrections were unfortunately not received until after the paper had been printed. Mr. O'Neil's letter is as follows:

"We are now using 3,200,000 gallons of water per day for each of the four stamps, or a total of 12,800,000 gallons. The free area through the intake crib grating is 45 sq. ft.; hence the velocity is 0.44 ft. per second. By putting in the second intake crib, enough water can be obtained to supply eight stamps 25,600,000 gallons, for which the tunnel was designed. In this case the velocity in the tunnel would be 1.10 ft. per second, which is low."

THE DANVILLE WRECK ON THE SOUTHERN R. R.

We briefly noted in our last issue the serious accident on the Southern R. R. near Danville, Va., on Sept. 27. We have since obtained from a local correspondent additional particulars concerning the wreck, together with a photograph taken shortly afterward, which is reproduced herewith.

The train which was wrecked was No. 97, a fast mail train, said to have the fastest schedule of any train on the Midland Division of the Southern Ry. The train consisted of a locomotive, two mail cars, an express car and a baggage car. It carried no passengers. The train was due at Danville at 1.30 p. m. It was about 40 minutes late, and was running at a very high speed, much higher, in fact, than the city ordinances allow.

The accident occurred just as the train entered a high trestle which spans a creek north of the city, and is on a steep grade and sharp curve, and, according to the best information, it was caused by the flange on a wheel of the engine breaking when the curve was struck. The train ran some distance on the trestle over the cross ties, and finally plunged over the side and fell 75 ft. into the water below. The coaches were piled on each other, and all but one were broken up into fragments. The locomotive was buried in the mud at the bottom of the creek, with the debris from the coaches piled around and about it.

The one car that remained intact broke through the trestle in its descent, making a large gap and delaying traffic on the road for several hours.

Fire broke out in the wreckage shortly after the accident, but was quickly extinguished by the Danville Fire Department, which was hurried to the scene as quickly as possible.

Of the 16 men who composed the train crew, 9 were killed and 7 seriously injured. The engineer, fireman and conductor were all killed.

A coroner's jury impanelled to ascertain the cause of the accident returned a verdict that it was due to an excessive rate of speed. The statement of Vice-President Finley, of the Southern R. R., printed in our last issue, gave the rate of speed as 30 to 35 miles per hour; other reports set it as high as 55 to 60 miles.

WRECK OF FAST MAIL TRAIN ON THE SOUTHERN R. R. AT DANVILLE, VA., SEPT. 27, 1903.

SOME POINTS IN THE DESIGN OF BUCKETS FOR IMPULSE WATER-WHEELS.

Impulse water-wheels, or "tangential" wheels, as they are frequently called, have received only a small fraction of the theoretical and practical study which has been put on turbine water-wheels of the reaction type. This is due, principally, we believe, to the fact that the elements and conditions of the problem, involving a free stream of water striking curved surfaces in motion, do not adapt themselves to analysis as readily as do the filled water passages of the turbine. The great extent to which impulse wheels have come into use, however, and the excellent results obtainable from them both in efficiency and in regulation, make it important to know the conditions under which they should work to give best results, and from these deduce the general principles which must govern their design.

With proper design of the supply piping and nozzles, for which well-known principles suffice, the problem reduces itself to the design of a wheel of such diameter, number of buckets and shape of buckets that the largest possible part of the energy in the stream flowing from the nozzle is turned to account by the wheel. The amount of energy given up to the wheel may be considered as the difference between the original energy of the stream and the losses of energy between stream and wheel. The study of these losses and how to avoid them is, then, the study of the wheel itself.

A good practical method for investigating the bucket losses of impulse wheels has been employed by Mr. G. J. Henry, Jr., in a series of experiments carried on during the past year or two. The method of study consists in observing visually or photographically how the stream of water behaves when it strikes the buckets. To get a proper length of exposure for an instantaneous photograph when the wheel revolves rapidly an apparatus was employed as shown in Fig. 1, herewith. An electric arc-lamp contained in a closed box throws a ray of light through an opening controlled by a shutter; this ray of light strikes a mirror below the experimental turbine and is reflected upwards through a glass window in the bottom of the casing, so as to illuminate the wheel, buckets and stream. The shutter controlling the ray is opened momentarily once during each revolution of the wheel, by a drive from the turbine-shaft, and the drive being synchronous causes the illumination to occur at the same instant in each revolution. The exposure of the photographic plate may then be of any duration desired, the successive images being identical, and the time of each flash may be made small enough to give a well-defined picture even at high speeds of the wheel.

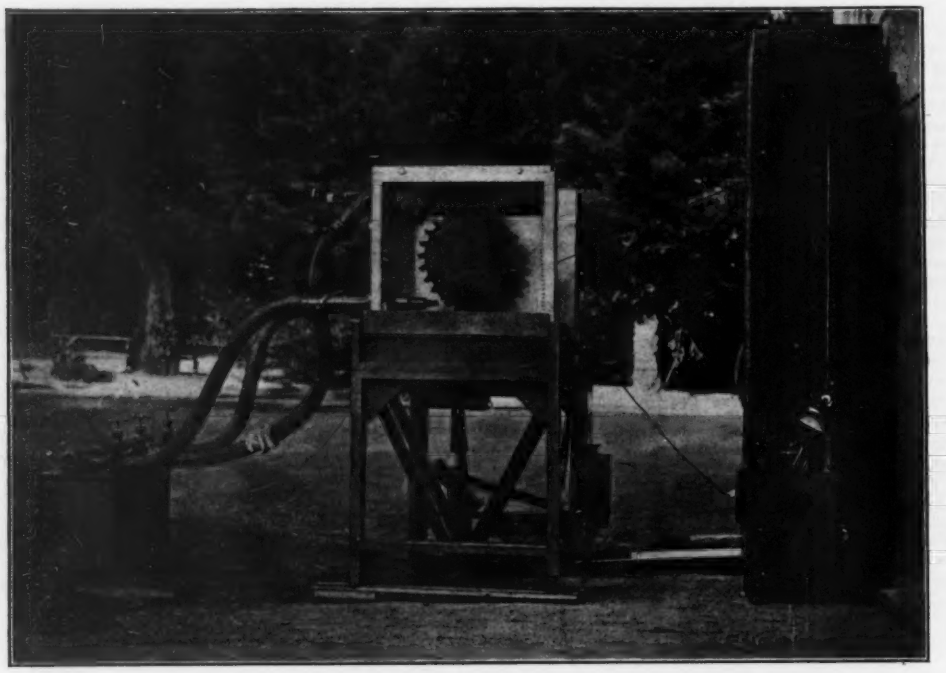


FIG. 1. APPARATUS FOR PHOTOGRAPHIC STUDY OF IMPULSE WHEELS.

Fig. 2. Pelton Wheel at Rest.

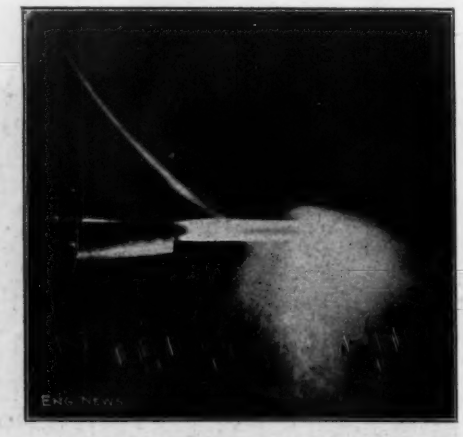


Fig. 3. Pelton Wheel at Full Speed.

The results obtained with this apparatus are well illustrated by the three views reproduced here as Figs. 2, 3 and 4. Fig. 2 is a photograph of a wheel with Pelton buckets, at rest, the stream from the nozzle striking the center of a bucket. The two following buckets being removed, the two parts of the deflected stream are clearly shown. Fig. 3 shows this wheel at full speed, the photograph being taken without using the instantaneous illuminating shutter device. The tailwater dropping away from the wheel here appears as a cloud without revealing the path of the water. In Fig. 4, taken with the use of the shutter, the course of the water can be traced out. One bucket is shown just entering the stream and another receives the main portion of the stream. The horizontal streamers indicate the path of the water which was discharged backwards from the preceding buckets.

A paper based on the observations made with this apparatus was read by Mr. Henry before the Pacific Coast Electric Transmission Association at San Rafael, Cal., on June 16, 1903, under the title "Tangential Water-Wheel Efficiences." Aside from the subject of bucket shape, a number of other interesting matters are touched on in this paper, such as the overcrowding of impulse wheels, wear and corrosion of buckets, etc., as will be seen from the following condensed reprint of the paper:

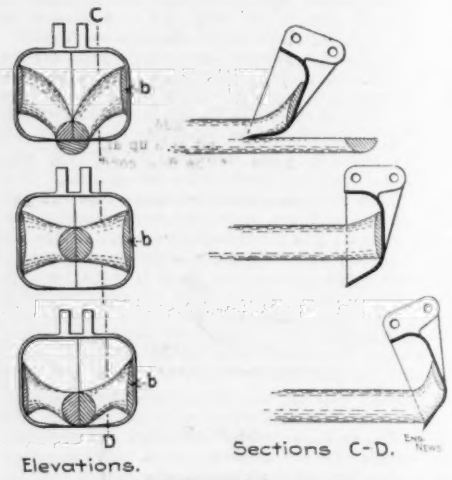


Fig. 5. Diagram Showing Course of Water in Pelton Bucket Under Normal Working.

Fig. 4. Pelton Wheel at Full Speed Photographed by Synchronous Flash Illumination.

To obtain the best efficiency from a water-wheel plant it is necessary to have the proper pipe line, gate valves, nozzles, water-wheels and buckets, wheel-case, wheel-pit and tail-race, and all of these parts must be properly designed for the particular conditions under which they are to operate, and all will vary with the head or pressure, the water quantity, and the revolutions which the wheel is to make. Many a water-wheel bucket has been overworked for years, and then charged up with losses that occur because of its being improperly worn, due to this overwork. Again, buckets are frequently charged up with all kinds of losses which are really due to something for which the bucket is not responsible. Pressure, or wheel diameter, or speed on a given wheel, cannot be varied radically without materially altering the efficiency. Many hydraulic plants are in operation and developing not over 65% between the flume and water-wheel shaft where the bucket itself is capable of developing 90%, and where a very inexpensive change could be made which would increase the gross efficiency very materially and cause a great saving in the water bills. On the other hand, there are probably more errors made in buckets than in any other one element of a tangential water-wheel plant.

Some inventors insist that buckets should discharge from the top or edge nearest the wheel center, as in the

Risdon and Hug. Others, again, that the discharge should be from the front and side furthest from the center, and still others, that this discharge should be from the sides, as in the Cazin, Berry Blue and Pelton. This latter class is by far the more numerous. In actual practice each bucket, of course, discharges to some extent on all three sides of the cavity, but the maximum discharge may be distorted to any particular point by changing the interior surface of the bucket cavity. Some inventors insist on few and others on many buckets located around the wheel periphery. In fact, the whole question of bucket design seems to be largely a matter of guess work, usually based on assumptions entirely at variance with facts, and therefore leading to wrong conclusions.

BUCKET LOSSES.—To obtain the best possible bucket efficiency it is necessary that the water jet be taken up on the bucket surface and brought to as near rest as possible with the least loss of energy. This loss will then be made up of: (1) The discharge velocity with which the water leaves the bucket with respect to a point fixed in space. Note that this velocity will vary with every position of the discharge as bucket moves. (2) Air and surface friction inside the bucket. (3) Imprisoned water in the bucket. (4) Variation in the stream form, producing erratic conditions of impact and flow on the bucket surface. (5) That occasioned by the stream being displaced by the entering bucket. (6) Eddy currents in the buckets. (7) Water which does not give up all its energy to the bucket (a special case of the first condition mentioned above).

There are still other losses which should form an important consideration in wheel design, but which are not directly affected by the bucket shapes. These are: Journal friction; windage due to the wheel acting as a centrifugal blower, and losses in the nozzles, gate valves and pipe lines. Every water-wheel plant has all of these losses to a greater or less extent, and it is obvious that when 80% is then obtained from an operating wheel, the improvement of any one of these, or, for that matter, the entire elimination of any single loss, if this were possible, would not, to any great extent, improve any wheel's gross efficiency. The writer has a number of times obtained as high as 90% efficiency in laboratory tests on buckets only.

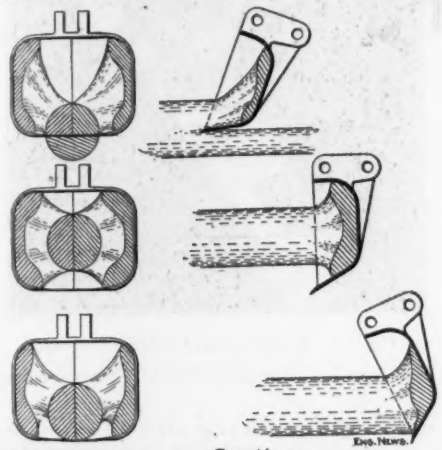


Fig. 6. Diagram Showing Course of Water in Pelton Bucket Worked Beyond Normal Capacity.

Let us give some attention to the chief of the above losses, and endeavor, as far as possible, to determine those points, the careful calculation of which will obtain for us the best possible tangential water-wheel bucket.

Given a certain stream of water at a given spouting velocity, it is advisable that this be taken upon the bucket surfaces of only just enough buckets to catch every particle of water on the dividing wedges and turn it all on the curved surfaces, and discharge it at just enough velocity (and entirely in a direction at right angles to the entering stream axis) to clear the next following bucket. The resulting velocity will then be the tangent of the discharge angle, multiplied by bucket velocity.

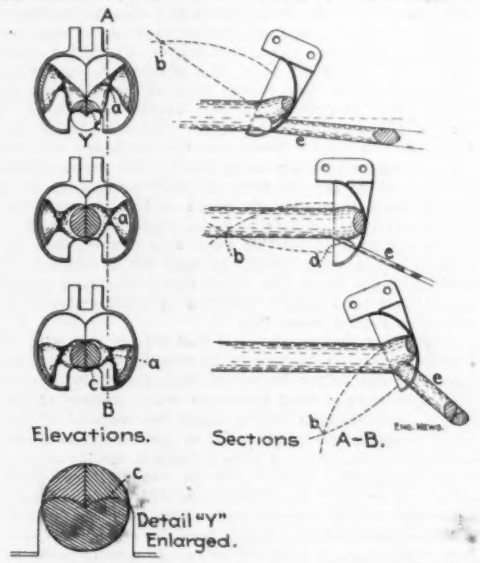


Fig. 7. Diagram Showing Action of Water on Bucket Having Double-Curved Surface, and Effect of Cutting Away Front Wall.

The air and surface friction must be maintained as small as possible by the use of a nozzle which will give a perfectly circular and solid stream. The bucket surface and cutting edges must be of a shape which, with a minimum wetted surface, will allow the stream, without crowding at any point, to spread out in a thin fan-like discharge on each side, in order to avoid eddy-losses in the bucket. The surface must be such that the water will not adhere, and as smooth as possible. The surface may be ground and polished, or better, ground and welf painted with a special compound. If all of these points are carefully studied out and the front of the bucket properly shaped and not cut away too low, imprisoned water will not cause any appreciable loss. The windage will be a minimum if the number and surface of the buckets is a minimum.

The above losses and considerations for their prevention are all of such a nature, and so entirely interdependent, that their quantitative value cannot be predetermined except in a general way. In designing a water-wheel, however, it is certain that the exercise of the most careful judgment is necessary in the laying out of the surfaces, so that all the losses, or at least their sum, or total bucket loss, will be kept down. Thus, if too much bucket surface be allowed, we increase both surface friction and windage for a given output, and if we attempt to cut these down by reducing the surface, we crowd the stream, so that eddy currents will occur and the stream will not properly discharge from the bucket side.

The accompanying diagram (Fig. 5) shows the course of a stream of water in a Pelton bucket under normal operation. The three positions shown are: (1) Bucket entering stream, (2) bucket in full action, and (3) bucket leaving stream. With this may be compared the similar diagram (Fig. 6) of a bucket overcrowded. The losses incurred by overtaxing a wheel are evident from a comparison of the two figures.

It will now be seen that it is absolutely impossible to get equally as good results from a certain shape of bucket under all conditions of wheel and stream diameter and water pressure, but that, to get the best efficiency, a bucket must be designed for each set of conditions. When an investigator says, "Suppose no frictional resistances exist in the bucket, and let the stream be prevented from spreading laterally—also neglect losses due to impact, loss of head in the nozzle, journal-friction and resistance of the air"—however interesting a conclusion he may come to mathematically, the result is not only entirely useless but frequently misleading to a dangerous degree. By carelessly omitting some of the above considerations, many makers who have obtained very good results on some one wheel, fail to secure even a reasonable efficiency from others, built on similar lines, but for working under different conditions. The writer believes also that there is no such thing as a bucket shape, which, by simply enlarging or reducing, may be adapted to any set of conditions.

Some of the familiar bucket types are grossly deficient in the most elementary requirements for efficiency and best practical results. All bucket shapes may be divided into two classes, in the first of which we have a variation in the shape of the cups on each side of the dividing wedge, and the second in which we vary the front wall or entering lip. Let us give some attention to these two points.

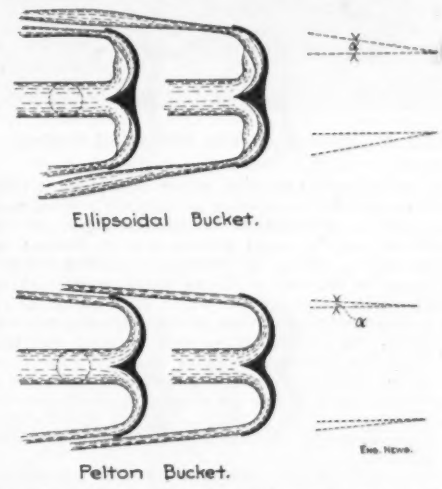


Fig. 8. Diagram Showing Effect of Node in Discharge Water on Angle of Discharge.

SINGLE-CURVED AND DOUBLE-CURVED BUCKETS.—In the first place, no stream of water can divide on the central wedge and gradually spread out, if the surface of the bucket is concave with a deepest point, as there will be a tendency for all the lines of flow to cross on this point and then spread out again after passing over it. (See diagram, Fig. 7. This and the following diagrams, as well as Figs. 5 and 6, were sketched from the observations made with the experimental apparatus described above.) This crossing or "impact accumulation" and the consequent eddy currents at the deepest point cause more rapid wear here than elsewhere, as also a considerable

Fig. 9.

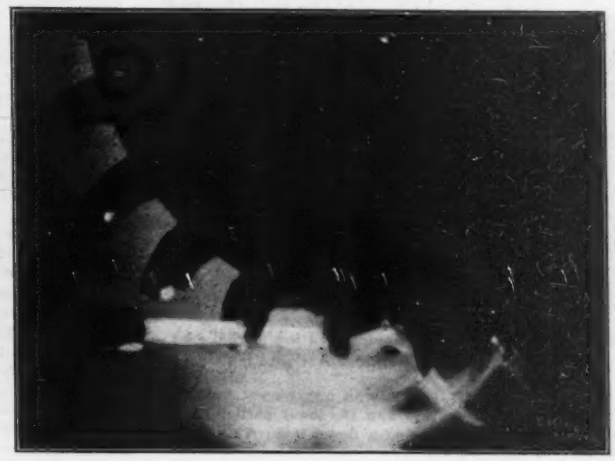


Fig. 10.

FIGS. 9 AND 10. PHOTOGRAPHS OF WHEEL HAVING BUCKETS WITH DOUBLE-CURVED SURFACE AND FRONT LIP CUT AWAY; AT REST AND AT FULL SPEED.

reduction in efficiency. The water again spreads out after crossing the deepest point, but before leaving the side of the bucket the curvature of the walls tends to produce a second node, which occurs after discharge. The decreased efficiency due to the greater discharge angle and the greater discharge velocity necessary to avoid interfering with the following buckets, with such a bucket shape, is suggested by the diagram Fig. 8. It is the writer's belief that there should be no single deepest point in a water-wheel bucket, but rather that the flowing stream after impact on the dividing wedge should follow practically a cylindrical surface, so that the stream may spread out in a fan-like shape at discharge, as shown in Fig. 5.

FRONT LIP OF BUCKET.—In reference to the front of the bucket, this should be neither too high nor too

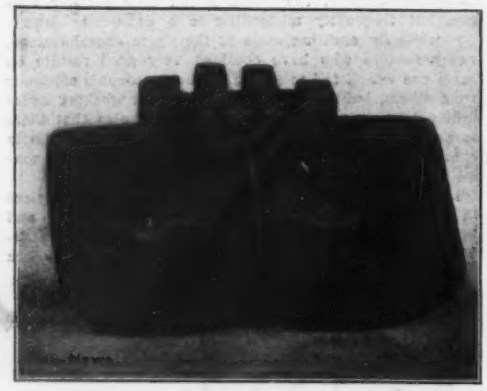


Fig. 11. Bucket Worn by Mechanical Erosion.

low. If the front be too high, then it must be set at such an angle of entry to avoid disturbing the stream, that there will be eddy currents set up; if too low, all the water will not be caught without a great increase in bucket surface. Under no circumstances should the entire front be left out, as in the bucket represented in Fig. 7. With buckets of this type, a large percentage of the water entering each bucket strikes a comparatively flat portion of the bucket. If we bear in mind that the efficiency of a flat surface running under the same conditions is theoretically only 50% (and practically much less) of the efficiency obtained when water is received on the wedge, we readily see that this loss, due to part of the stream striking on a flat surface, drags down the efficiency of the bucket.

The action of buckets having a deepest point and having the front lip cut out is well shown by the two photographs, Figs. 9 and 10, which may be compared with the diagram, Fig. 7. Fig. 9 shows the wheel at rest, while Fig. 10 shows it running at full speed. Fig. 9 shows the node formation in the discharge, and the resulting spraying and large discharge angle; it also shows how the bucket divides the stream into three parts (which is generally claimed not to occur with this type of bucket,

Fig. 12. Worn Bucket Showing Pitting, Believed to be Due to Chemical Action.

but which necessarily occurs with any bucket having a central dividing wedge) and how the lower portion of the stream is wasted, resulting in a direct loss. This loss is also evident from Fig. 10.

The entry of the bucket front into the stream, if properly made, can be the cause of but an infinitesimal amount of power loss, if any. In fact, a bucket to give anywhere near a proper efficiency, in addition to the reason given above, must have a considerable front wall, otherwise after impact has occurred on the bucket surface the jet will spread and a large percentage of it will find its way out, without having given up more than a small part of its energy. This is true not only during entry, but during the entire passage of the bucket through the stream, and paradoxical as it may seem it is a fact that a greater disturbance in the stream, as concerns the conditions requisite for maximum efficiency, is caused by cutting down the height of the front wall below the splitting wedge than by leaving it well up.

WEAR AND EROSION OF BUCKETS.—There is another branch of this subject which is of considerable interest, and which, if carefully studied, leads us to very important conclusions, viz., the erosion or bucket wear which occurs in every plant to a greater or less extent. As stated before, the course followed by a stream of water, after impact on a Pelton bucket, is such as to give a discharge almost entirely from the side of the bucket. The course taken by the discharge will be slightly different as the wheel rotates, but the discharge will always be parallel with the entering jet. If these statements are correct, we would find in properly designed and installed Pelton plants, where all the adjustments and sizes of streams used were correct, that the buckets would wear evenly, at least for a considerable time, until the slight pits, which almost invariably occur, would start local action, resulting in considerable wear spreading around these pits.

It is a fact worthy of notice that erosion met with in hydraulic practice is usually of two kinds. First, we have that due to the impact of cutting particles, which acts exactly as a sand blast—the sharp corners of the quartz sand particles cutting away the material of the bucket surface. A bucket eroded by this process is shown in Fig. 11. Secondly, we have a chemical erosion or corrosion, occasioned, I believe, by the escape of imprisoned air or air or other gas in solution, which released suddenly under high pressure may carry with it a certain amount of nascent oxygen, which on the clean metal surface would promote rapid oxidation. It usually starts at any imperceptible inequality in the castings, such as infinitesimal blow holes. The water moving over the surface and jumping across the blow hole crater releases the oxygen of the air, possibly more readily than the nitrogen. This gives us a small pocket, or blow hole, having clean surfaces from the water friction, filled largely with oxygen gas. The oxygen combines with the clean metal forming an oxide coating, which is cleaned off by the water friction, which will invariably occur at the slightest change in position of bucket. The result is that the oxidizing process is repeated—the hole rapidly growing larger.

We would expect, if the above theory of chemical erosion is correct, to find the oxidized pits, as they become larger, increasing more rapidly in the direction of the bucket wedge, or creeping towards the direction from which the stream approaches, rather than from it, as the oxygen would naturally be released on the side of the pit from which the stream approaches. Such seems to be actually the fact where we can obtain an example of chemical erosion independent of mechanical erosion.

Fig. 12 shows you a bucket taken from one of the wheels at the Santa Ana Station of the Edison Electric Co. after about 27 months' operation, during which it was driving a 750-KW. generator from a single stream under about 700 ft. head. Here you will find the oxidized pits above mentioned, which are of the color of gun metal—the oxidized depressed surfaces being clearly outlined from the smooth steel surface over which the water flows. If the erosion of these pits were due to eddy currents, the oxidized surface would be removed by such erosion. Moreover, if mechanical erosion accounted for the pitted surface of most of our water-wheels, we would find the dividing knife, or splitter, the most heavily worn part. This, however, is not the case in most instances, the pitting usually occurring in the bottom and sides of the cavities. It will be readily seen that, after these pits grow large enough to alter the course of the water, they will completely change the path of the jet in the bucket cavities, and we will then have all sorts and kinds of erratic shapes, which shapes are in no way governed by the original curves of the buckets. We thus find on the same wheel buckets worn through in entirely different spots, bearing absolutely no similarity to each other, although they all started out under exactly equal conditions.

In water jets carrying imprisoned air, or air or gas in solution, due to the high pressure, we would expect to find, on relieving this pressure, a gas discharge from the outside of the stream. Fig. 13 shows you a stream under 50-ft. head, carrying air in solution. The stream at the instant of leaving the tip is perfectly clear; an instant later, or about two diameters from point of issue, we find a slight enlargement of the stream, which the writer believes to be due to the imprisoned gas freeing itself on the relief of pressure. This disengaging process continues in this instance for about fifteen stream diameters, after which the stream begins to again clear up, although at no point is its rigidity or shape interfered with. Fig. 14 shows you another example, and under such radically different conditions as to lead me to the belief that this condition exists throughout the entire field of hydraulic practice. You see here a jet from a Pelton needle nozzle under a pressure in excess of 1,900 ft. head at the plant of the Edison Electric Co. in southern California. The jet is of a size suitable for developing an overload on a 750-KW. generator, and the fog or "water dust" immediately surrounding the jet shows clearly the disengagement of imprisoned gas. This is best observable at from one to ten diameters from the tip, and is undoubtedly a condition that exists on the bucket surface, as well as immediately surrounding the jet at point of issuance.

EROSION IN NOZZLES.—It is perfectly obvious, if this theory is correct, that much of the wear that occurs in the interior of nozzle tips would also be explainable. For it is certain that where changes of cross section occur, there is a corresponding change in stream velocity and, when this is not in accordance with the laws of least

Fig. 13. Stream Under 50-Ft. Head.

Fig. 14. Stream Under 1,923-Ft. Head.
Views Showing Disengagement of Air from Stream.

resistance, the oxygen or other gas would be released in exactly the same way—causing the pitting surfaces in side of the nozzle tip. Fig. 15 shows an eroded nozzle tip. This nozzle had a constriction near the middle, and beyond this the erosion is chemical, while this side of the constriction only mechanical erosion was active.

I believe this to be the correct explanation of chemical corrosion, and think that in most cases in practice we have a combination of chemical and mechanical erosion.

PAINTING BUCKETS.—Paint acts exactly as a sheet of paper or rubber cushion protecting a piece of glass under a sand blast—the paper or rubber not in any way being damaged by the impact of the particles of sand, but where cut away so that the glass is exposed to the cutting grains, the hard surface of the glass or of tool steel will

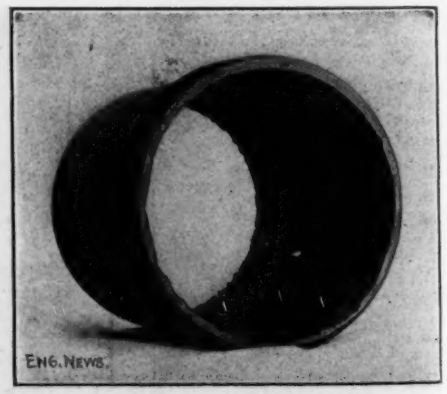


Fig. 15. Worn Nozzle, Having Neck in Center, Showing Erosion and Pitting.

be very rapidly cut. By holding your finger under the sand blast, the finger nail is rapidly cut away, although the sand makes no impression on the softer skin surrounding it. The observation of this fact led the Pelton company years ago to adopt a special rule in regard to painting its buckets—the paint proving the best possible protection. In fact in regular operating plants, if the buckets are of good design and are kept thoroughly painted, they will last an indefinite length of time.

THE MAKING OF 18-INCH STEEL EYE-BARS.

By Wm. R. Webster,* M. Am. Soc. M. E.

The advances made in the manufacture of steel eye-bars were gradual until the last few years. When steel eye-bars were first made, it took from eight to ten heats to make a finished head. The greatest difficulties have always been experienced in the forging of the narrow thin bars on account of their buckling vertically in upsetting, thus forming cold shuts and in deflecting sidewise under the upsetting pressure. In some cases, it has been the practice to upset two of such thin bars at a time.

As the size of the bars was increased, it was found less difficult to upset and forge the heads than with the thinner bars. But a new difficulty was encountered in the full-sized tests of such bars; they frequently broke in the neck, head or body of the bar showing a granular fracture, small reduction of area and per cent. of elongation. In one case that I have in mind, a lot of 10-in. bars of acid open-hearth steel were rolled into varying thicknesses from the same heat of steel and the chemical composition and small tension tests were very satisfactory. The eye-bars were made under similar conditions, annealed at the same temperature, yet the full-sized tests of these eye-bars were such that the thick bars on this heat of steel were rejected and the thin bars accepted. A large series of full-sized tests were made from these bars in order to locate the trouble and it was found that it was due to the thick bars having been finished at too high a temperature in rolling. The ordinary annealing does not always restore the heavy bars that have been injured in this way, and the tension and bending tests on small specimens will not always show such injury.

This trouble with heavy bars became a serious matter and a large series of bending tests on full-size bars was made in order to have some good reliable check on the material as it came from the rolls and before upsetting and forging the bars. The results of these tests were so satisfactory that a clause has been put in several of the recent specifications for eye-bars calling for full-sized cold bends of the bars as they come from the rolls. In order to roll bars to comply with this, it is necessary to finish them at a lower temperature than formerly which may cut down the output in rolling somewhat, and thus necessitate a slightly higher price, but the corresponding benefits in getting reliable material for the eye-bars are so great that the additional cost is justified.

A great many of our specifications have the following clause in them:

"When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing."

This seems at first sight to be reasonable and justified by general conditions, but on eye-bar material, to which it particularly applies, it is the worst clause that was ever made part of a specification and has done more to get the manufacturer into trouble with the full-sized tests and prevent progress in the manufacture of eye-bars, than anything else. Bars accepted under these conditions were rolled at "any old temperature." The samples cut from bars were carefully annealed and gave satisfactory results but in no measure were these samples a criterion of the condition of the bars as rolled. The heating for upsetting and forging increased the trouble which the subsequent annealing did not remove. As many of our eye-bars were made under these conditions, it is not to be wondered at that the advance in the use of large thick eye-bars has been very slow. All the conditions of heat treatment required are now thoroughly understood. Results of full-sized tests of thick eye-bars recently published confirm this statement.

It is an important matter to have sufficient thickness in the wide bar to prevent the head from dishing. In making tests of wide thin bars it is always customary to wedge each side of the head in the testing machine to prevent this dishing. I refer to this, as it is one of the objections to the use of eye-bars or links cut from wide thin plates as is customary in Europe. Another objection is that these plates have always been used in the condition in which they leave the rolls without the beneficial effects of annealing.

All that has been said applies equally to ordinary carbon steel or to nickel steel. The increase in size of grain from heat treatment is greater with the higher carbon steels than with the low carbon steels, therefore, when a high tensile strength and elastic limit are required in large bars, steel containing 3½% of nickel has special advantages, as this amount of nickel replaces about 0.15% of carbon and the steel can be worked with greater safety. It gives a higher ratio of elastic limit to ultimate strength and is a tougher material, giving better stretch and bend. This nickel steel works well in upsetting and forging, and full-sized tests of all eye-bars made of it up to this time have given very satisfactory results.

Corresponding advances have been made in the annealing of eye-bars, in the matter of charging the bars in the annealing furnace, carefully observing the annealing temperature and in the method of cooling. The most recent specifications for eye-bars, that for the Blackwell's Island Bridge provides several conditions to insure proper material only being sent to shop to be manufactured into eye-bars, also several checks to test the upsetting, forging and annealing, with full-sized tension tests of the finished bars, all of which will undoubtedly secure reliable bars for the structure.

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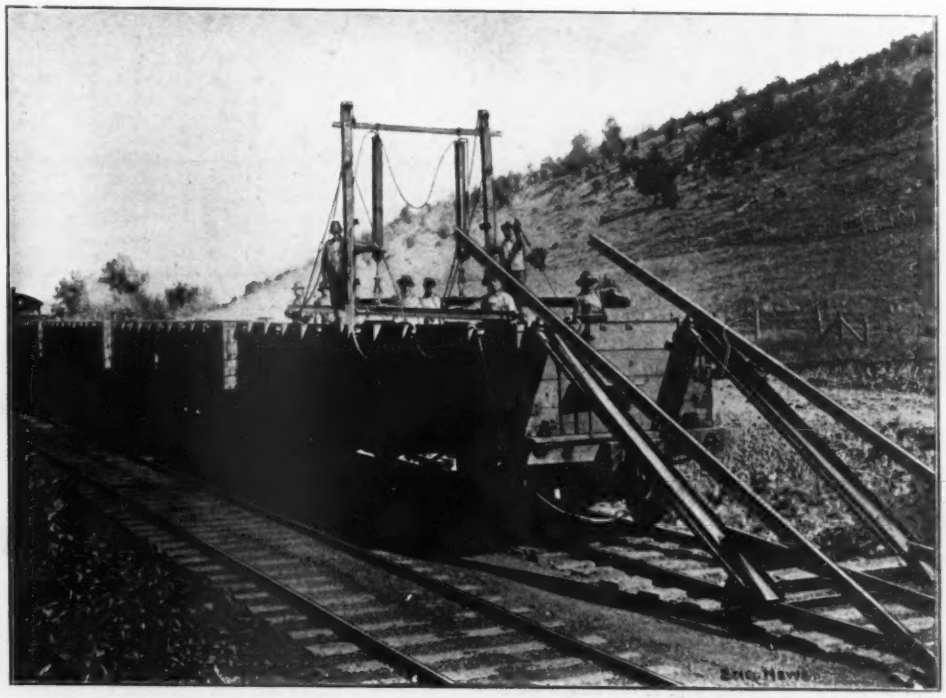
A PNEUMATIC DEVICE FOR UNLOADING RAILS FROM WORK TRAINS.

In distributing rails alongside the track for renewals, the general practice is to use flat cars, although gondola cars with removable ends or gates are sometimes employed. In some special cases, however, the rails are carried in cars without removable ends, and it then becomes important to devise means for handling and unloading the rails. On the Buffalo, Rochester & Pittsburg Ry., rails are frequently hauled in gondola cars with permanent sides and ends, usually used for coal traffic. As these cars have sides 4 ft. 4 ins. high it would not be an easy matter to unload the rails by hand, even if the men were allowed to drop them over the side of the car. This dropping of rails from a height, however, should never be permitted, as it is liable to result in serious damage to the rail.

In order to facilitate the rapid and safe unloading of rails from cars of this type, a pneumatic device has been designed and patented by Mr. Henry Ware, Roadmaster of the Buffalo Division, at Springville, N. Y., and we are indebted to him for photographs and information. The accompanying cut shows the device in use.

A removable gallows frame is set on the sides of the car, the uprights resting directly upon the sides and being secured by adjustable stake pockets. The pocket is so formed that it straddles the side of the car, and is adjusted by a vertical wedge, so as to fit any width or kind of car. The uprights are secured longitudinally by brace rods, and are connected at the top by an iron bar, from which are suspended the two air-hoist cylinders. From the end of the car is hung a skid frame, consisting of two channel-shaped skids, connected at their lower ends by a cross beam resting in lugs riveted to the skids. At each end of this cross beam is a small flanged wheel running on the track rail. At the head of each skid is a roller, which is in line with another roller on the inner side of the upright of the gallows frame. The piston rods of the hoists carry rail tongs, as shown.

In operating this device, four men are required to each cylinder, making eight men to unload two rails at the same time. There is one man at the cylinder, one at the tongs, and one at each end of the rail. The cut shows the manner in which the rails are raised from the bottom of the car. When the rail is lifted to a sufficient height, the men guide it so that it will rest on the roller attached to the inside of the upright and the roller on the head of the inclined skid attached to the end of the car. When the rail is so placed, the suspending tongs are released from the rail and the men, with very little effort, start the rail toward the end of the car. When the center of the rail passes over the roller at the head of the incline it tips up, as shown by the inclined rails in the cut, and the end slides to the ground. As the train moves along, the upper end of the rail slides down till it rests on the ground or the ends of the ties. The air for the pneumatic cylinders is taken from the brake hose at the end of the rear car, as shown in the cut.



AIR HOIST FOR UNLOADING RAILS ON THE TRACK; BUFFALO, ROCHESTER & PITTSBURG RY.
Henry Ware, Inventor; Roadmaster, B., R. & P. Ry., Springville, N. Y.

It is found that with very little experience on the part of the men the train can be kept almost constantly moving as the work of unloading is going on, and the work is done entirely by the regular section men. This apparatus in its present condition has been in use but a short time, but Mr. Ware states that it has fully demonstrated its practicability and usefulness and that by its use the cost of unloading rails is greatly reduced,

the laborious work of lifting them by hand is entirely eliminated and their unloading without damage is fully assured.

THE PENNSYLVANIA R. R. TUNNEL UNDER THE HUDSON RIVER AT NEW YORK CITY.

After nearly two years of labor the Pennsylvania R. R. has completed the contract plans and specifications for a tunnel railway under the Hudson River, Manhattan Island, and the East River, to connect its New Jersey and Long Island railway systems. Bids for the construction of the work, according to these plans and specifications, will be received until Dec. 15, 1903. The work as planned is without doubt one of the boldest and most original tasks of subaqueous tunneling that has ever been undertaken and its prosecution and completion will be watched with interest throughout the world. In this issue it is possible for us to give only a general outline of the work proposed because of the late hour at which the plans were available for publication. In the accompanying drawings the reader will find, therefore, only the profile of the North River division of the work and a cross-section of the tube tunnel carried on screw piles, which undoubtedly ranks first among the novelties of the work. These plans will be followed in our next issue by details of all parts of the work and with a full description of the design and construction.

The North River section of the Pennsylvania R. R. tunnel begins at Ninth Ave., in New York

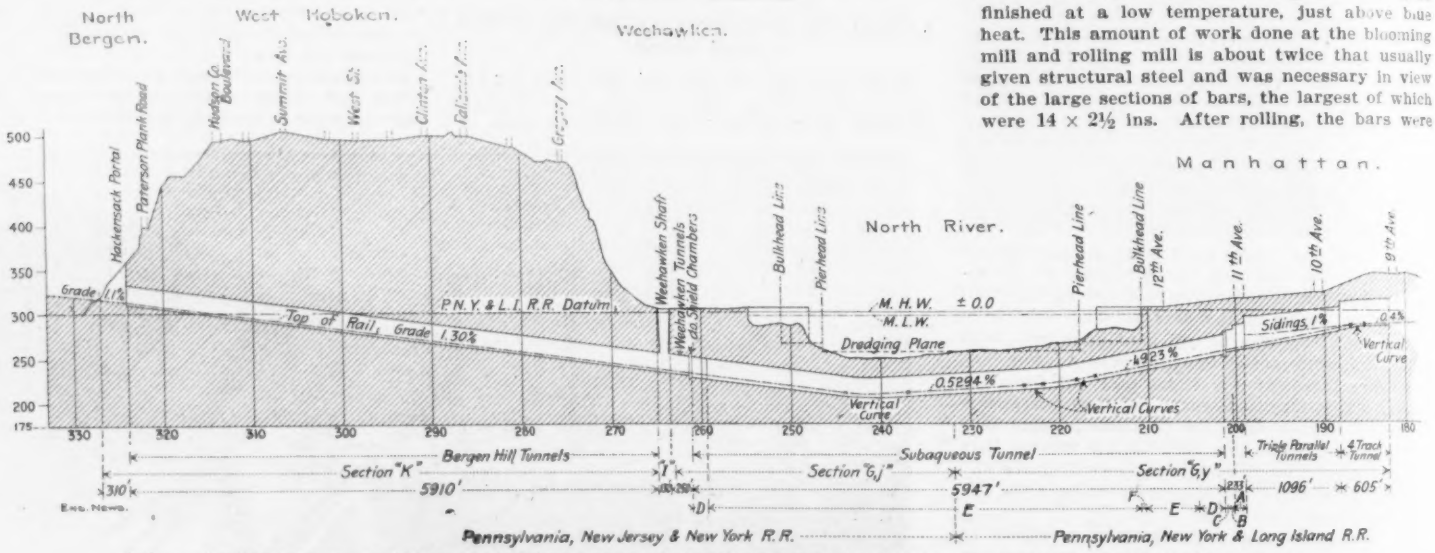


FIG. 1. LONGITUDINAL PROFILE OF NORTH RIVER DIVISION OF PENNSYLVANIA R. R. TUNNEL AT NEW YORK CITY.

A—34-ft. Span Arch.
B—20-ft. Span Twin Tunnels.
C—Shield Chambers.
D—Cast-Iron Lined Tunnel, resting on solid ground, without pile foundation.
E—Cast-Iron Lined Tunnel, with pile foundation.
F—Cast-Steel Lined Tunnel, with pile foundation.

city, and extends west on a tangent to an outlet onto the Jersey Meadows, near North Bergen, N. J. The total length will be 14,351 ft., or about 2.71 miles, and the East River section when added will bring the total length from New Jersey to Long Island to about 5.7 miles.

Referring for the present only to the section illustrated by the profile Fig. 1, the following general features of construction will be noted. Beginning at Ninth Ave., the structure for 605 ft. west is designed for four tracks in a single tube, the roof of which is supported by steel trusses. The succeeding 1,096 ft. are triple tunnel of generally rectangular section of columns and roof beam bents enclosed in concrete. This wide tunnel narrows down by means of a 34-ft. span concrete arch section 130 ft. long and a twin-tube section of 20 ft. span 75 ft. long to the first section of cast-iron lined twin-tube tunnel. This first section of twin-tube tunnel is 285 ft. long and is unsupported by piles. Then follows the subaqueous section proper, which is 4,859 ft. long, reaching nearly across the wetted perimeter of the river, and which consists of parallel concrete lined cast-iron tubes, each supported on a row of 30-in. screw piles spaced 15 ft. apart. The drawings of Fig. 2 illustrate typical cross-sections of this portion of the tunnel. There is then another length of tubes without piles, after which follows the land tunnel under the heights west of Weehawken, New Jersey. This land tunnel consists of two parallel full-center arch tunnels 5,910 ft. long.

Altogether there will be on this division of the work, 5,947 ft. of subaqueous tunnel, of which 4,859 ft. will be of the pile-supported construction shown by Fig. 2, and will pass through the unstable silt forming the bed of the North River. The other details of the construction as already stated are postponed for consideration in our issue of next week, so that time and space will be available for their proper presentation and discussion.

In conclusion it should be noted that the preparation of the plans and specifications has been in the hands of the Board of Consulting Engineers employed by the Pennsylvania R. R., and composed of the following persons: Lieut. Col. Charles W. Raymond, U. S. Engineer Corps; Mr. Gustav Lindenthal, M. Am. Soc. C. E.; Mr. Charles M. Jacobs, M. Inst. C. E.; Mr. Alfred Noble, M. Am. Soc. C. E.; Mr. Wm. H. Brown, Chief Engineer Pennsylvania R. R., and Mr. George Gibbs, M. Am. Soc. M. E.

THE METHOD OF MANUFACTURING THE LARGE EYE-BARS FOR THE THEBES BRIDGE.*

By P. S. Hildreth.†

In view of the general discussion regarding the manufacture of eye-bars, those for the Thebes Bridge, as being the largest used in bridge construction to date, are of special interest. This structure is a cantilever bridge for the Southern Illinois & Missouri Bridge Co., over the Mississippi River, consisting of two fixed spans 521 ft. 2 ins. long, four cantilever arms 152 ft. 6 ins., and three suspended spans 366 ft. long, giving the longest clear span of 671 ft. The following description of manufacture is abstracted from the report of Hildreth & Co., inspecting engineers, of New York city.

The general contract was placed with the American Bridge Co. The manufacture of the eye-bars was assigned to the new shops of the Ambridge plant, and the material was rolled on the new 42-in. universal mill of the Homestead Mills of the Carnegie Steel Co. Special care was taken by all parties in interest to secure most perfect material and manufacture in accordance with the highest standard of bridge construction.

STEEL.—The steel was made by the basic open-hearth process of a special mixture containing about 50% of low phosphorus pig iron and about 50% of selected steel scrap. Four furnaces were used exclusively in making this steel, in order to secure a uniform quality. The chemical analyses showed carbon about 0.28, manganese 0.45 to 0.55, phosphorus 0.01 to 0.025, and sulphur 0.0[illegible] to 0.042.

The specifications required under tens[illegible] tests an ultimate strength of from 62,000 to 70,0[illegible] lbs. per sq. in., and an elastic limit of not less t[illegible] 33,000 lbs., and a minimum elongation in 8 [illegible] of 22%, and a reduction of area of 44%. The[illegible] quirements were met in the accepted steel a[illegible] the ultimate strength ran in nearly all cases f[illegible] 64,000 to 68,000 lbs. The elongation generall[illegible] exceeded 25% and the reduction of area exce[illegible] 46%. Bending tests for the full thickness of [illegible] bars made cold after heating to cherry red a[illegible] quenching, bent 180° around a diameter equa[illegible] three-quarters the thickness of the sample wit[illegible] crack or flaw.

MILL MANUFACTURE.—The detail[illegible] of the mill manufacture were as follows: The [illegible] from the open-hearth furnaces was poured int[illegible] molds, making an ingot in section 30 ins. square and weighing about 5,500 lbs. When cold enough to strip the molds, they were taken to the blooming mill and put into the soaking pit for about six hours, then bloomed down to a section 16 ins. square. From these blooms sufficient crop ends were cut off to give subsequent sound material. While still hot the blooms were put into reheating furnaces and heated to as high temperature as possible without injuring the steel and then rolled on the 42-in. universal mill into the finished bars. In the process of blooming the ingots received 29 passes, and were turned at the tenth, twentieth and twenty-fourth pass. In the universal mill the blooms received from 52 to 56 passes and were finished at a low temperature, just above blue heat. This amount of work done at the blooming mill and rolling mill is about twice that usually given structural steel and was necessary in view of the large sections of bars, the largest of which were 14 × 2½ ins. After rolling, the bars were again sheared and from 3 to 6 ft. was cut off each end. No special effort was made to do accurate straightening, this being left to be done at the eye-bar shop. The finished bars at the mills were carefully inspected and such inspection resulted in rejections as reported in detail. The proportion of rejections decreased as the rolling proceeded. The greatest number of defects were seams and split ends. Occasionally bars were condemned for ragged ends, pits, cinder spots and scant section. In general the principal cause of rejection seemed to be from the fact that the blooms were not sufficiently sheared. As a lot, the bars were exceptionally satisfactory, and the proportion of condemnations was probably less than usual, considering the large tonnage.

SHOP MANUFACTURE.—The steel flats were shipped to the Ambridge plant of the American Bridge Co., and there manufactured into finished eye-bars. The process was the usual one by upsetting, and is remarkable for the size of the machinery, the care exercised during the annealing, and the general handling of large bars quickly and with satisfactory results.

The ends of bars were heated in a heating furnace and upset in the large hydraulic upsetting machine which upsets the head starting with a pressure of 900 lbs. per sq. in., and increasing to

*A general description of the Thebes Bridge was published in Engineering News of Nov. 20, 1902.

†50 Broadway, New York City.

4,100 lbs. per sq. in. During this pressure the upper and lower surfaces of the head were held flat by a vertical pressure of 6,000 lbs. per sq. in. The first heavy bar, 2½ ins. thick, 14 ins. wide, with heads 32½ ins. wide, was successfully made in three upsets to each head on Sept. 21. The subsequent heads of these heavy bars were made in two upsets, and with most excellent results. No difficulty was experienced with the 10-in. bars, except scale on heads and rough surface when cleaned, but with the 14-in. bars, 1⅜ ins. to 1 11-16 ins. thick, the metal did not flow easily and uniformly, and these bars required generally four heats and upsets, and some of them, seven. The final results were satisfactory, although the heads were not as smooth as the larger bars or as the best hammered heads.

After upsetting the heads of the bars, they were passed through heavy rollers which smoothed the surface, and if any material had flowed out beyond the head of the bar at the sides, it was sheared off hot in a special machine for this purpose, and the sheared surface was subsequently carefully chipped and dressed. Arrangements are being made to do this with a milling machine. The pin holes were then punched 1-in. less in diameter than the size of the finished hole. When cold enough to handle, the bars were straightened in a heavy press, with special care not to distress the material by attempting to accomplish too much straightening at any one time.

ANNEALING.—The bars were then piled in piles of from ten to 16 and run into an annealing furnace on machine-driven rollers, which during the process of annealing were turned back and forth so that all parts of the metal got a uniform heat and there was no tendency to sag between the rolls.

Annealing was done with an oil flame so arranged that it did not strike directly against the bars, but passed around them and was continued for from five to seven hours, the temperature being raised to about 1,400°, at which point the steel is non-magnetic. The temperature was then allowed to fall to from 650° to 700° and the bars run out and allowed to cool in the air. When cool enough to handle, the bars were finally and carefully straightened, and when thoroughly cold were bored in a boring machine of modern design adjustable to bore an exact length between centers. Not less than ½-in. of metal was removed around the punched holes. The finished bars were straight, and although the heads were somewhat rougher on the flat surface, due to scale, and slightly rough when dressing is required to remove excess metal at the sides, the necks of the bars were smoother and more satisfactory than those of hammered bars.

The general results of manufacture of these bars were highly satisfactory, and the process appears to be a marked advancement in bridge manufacture.

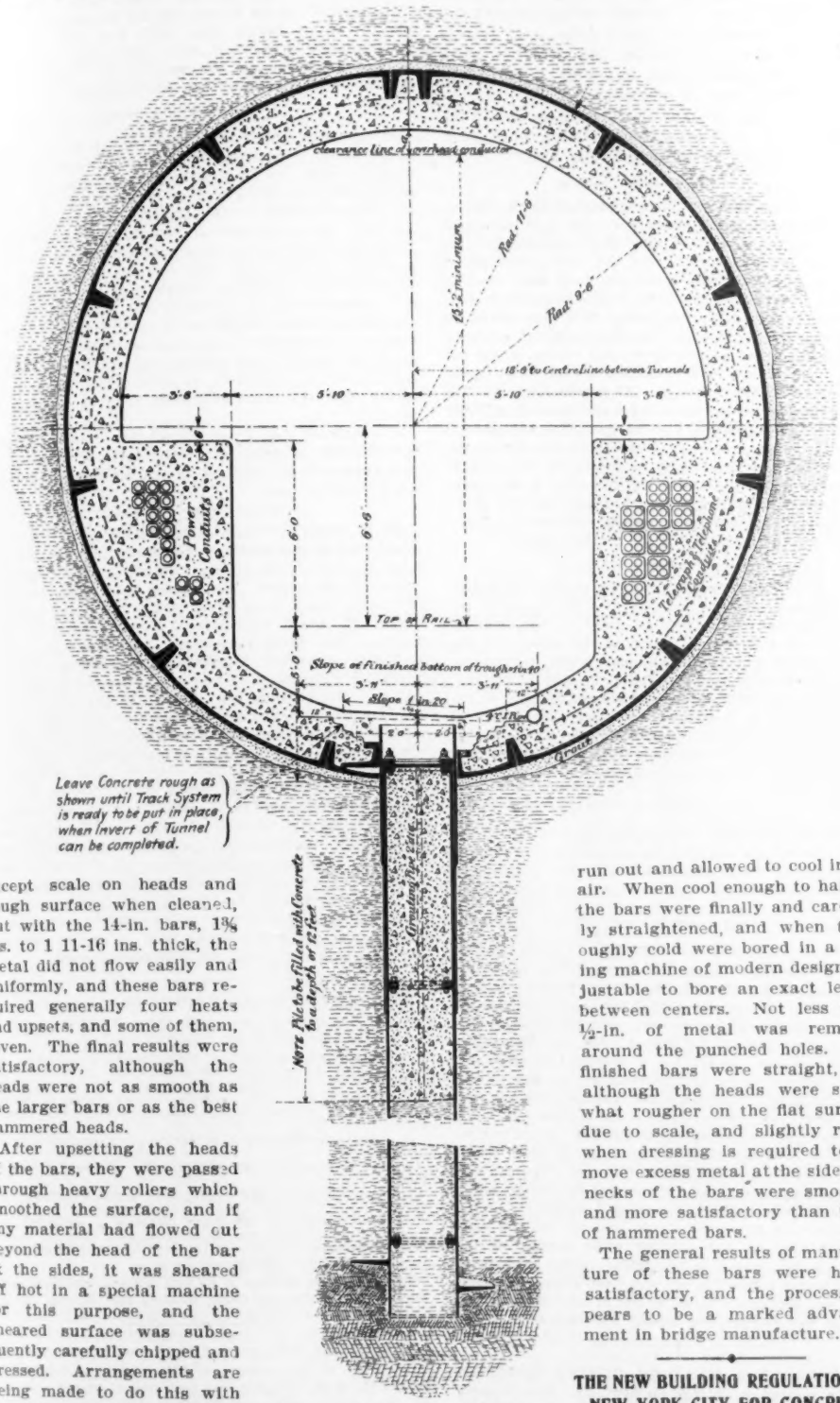

Clearance line of northeast conductor
Rad. 11'-6"
Rad. 9'-6"
18'-6" to Centre line between Tunnels
5'-6"
5'-10"
5'-10"
5'-6"
Power Conduits
Telegraph & Telephone Conduits
TOP OF RAIL
Slope of Finished bottom of trough 1 in 10
Slope 1 in 20
Leave Concrete rough as shown until Track System is ready to be put in place, when Invert of Tunnel can be completed.
Note. Pile to be filled with Concrete to a depth of 12 feet

FIG. 2. TYPICAL SECTION OF SUBAQUEOUS TUBE TUNNEL SUPPORTED BY SCREW PILES.

THE NEW BUILDING REGULATIONS OF NEW YORK CITY FOR CONCRETE-STEEL CONSTRUCTION.

The first instance of the official recognition of concrete-steel as a building material in the United States that has come to our notice is furnished by the set of rules which has just been issued by Mr. Henry S. Thompson, Superintendent of Buildings of Manhattan Borough, New York city. The importance of this step and the probability that it is an example which will be followed by other large cities within a few years make these rules worthy of publication in full, and we accordingly present them here:

1. The term "concrete-steel" in these Regulations shall be understood to mean an approved concrete mixture reinforced by steel of any shape, so combined that the steel will take up the tensional stresses and assist in the resistance to shear.

2. Concrete-steel construction will be approved only for buildings which are not required to be fireproof by the Building Code, unless satisfactory fire and water tests shall have been made under the supervision of this Bureau. Such tests shall be made in accordance with the Regulations fixed by this Bureau and conducted as nearly as practicable in the same manner as prescribed for fireproof floor fillings in Section 106 of the Building Code. Each company offering a system of concrete-steel construction for fireproof buildings must submit such construction to a fire and water test.

3. Before permission to erect any concrete-steel structure is issued, complete drawings and specifications must be filed with the Superintendent of Buildings, showing all details of the construction, the size and position of all reinforcing rods, stirrups, etc., and giving the composition of the concrete.

4. The execution of work shall be confided to workmen who shall be under the control of a competent foreman or superintendent.

5. The concrete must be mixed in the proportion of one of cement, two of sand and four of stone or gravel; or the proportions may be such that the resistance of the concrete to crushing shall not be less than 2,000 lbs. per sq. in. after hardening for 28 days. The test to determine this value must be made under the direction of the Superintendent of Buildings. The concrete used in concrete-steel construction must be what is usually known as a "wet" mixture.

6. Only high-grade Portland cements shall be permitted in concrete-steel construction. Such cements, when tested neat, shall, after one day in air, develop a tensile strength of at least 300 lbs. per sq. in.; and after one day in air and six days in water shall develop a tensile strength of at least 500 lbs. per sq. in.; and after one day in air and 27 days in water shall develop a tensile strength of at least 600 lbs. per sq. in. Other tests, as to fineness, constancy of volume, etc., made in accordance with the standard method prescribed by the American Society of Civil Engineers' Committee may, from time to time, be prescribed by the Superintendent of Buildings.

7. The sand to be used must be clean, sharp grit sand, free from loam or dirt, and shall not be finer than the standard sample of the Bureau of Buildings.

8. The stone used in the concrete shall be a clean, broken trap rock, or gravel, of a size that will pass through a ¾-in. ring. In case it is desired to use any other material or other kind of stone than that specified, samples of same must first be submitted to and approved by the Superintendent of Buildings.

9. The steel shall meet the requirements of Section 21 of the Building Code.

10. Concrete-steel shall be so designed that the stresses in the concrete and the steel shall not exceed the following limits:

	Lbs. per sq. in.
Extreme fiber stress on concrete in compression	500
Shearing stress in concrete	50
Concrete in direct compression	350
Tensile stress in steel	16,000
Shearing stress in steel	10,000

11. The adhesion of concrete to steel shall be assumed to be not greater than the shearing strength of the concrete.

12. The ratio of the moduli of elasticity of concrete and steel shall be taken as 1 to 12.

13. The following assumption shall guide in the determination of the bending moments due to the external forces: Beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates, when constructed continuous and when provided with reinforcement at top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than $\frac{W\,L}{10}$; the bending moment may be taken at $\frac{W\,L}{20}$ in the case of square floor plates which are reinforced in both directions and supported on all sides. The floor plate to the extent of not more than ten times the width of any beam or girder may be taken as part of that beam or girder in computing its moment of resistance.

14. The moment of resistance of any concrete-steel construction under transverse loads shall be determined by formulæ based on the following assumptions:

(a) The bond between the concrete and steel is sufficient to make the two materials act together as a homogeneous solid.

(b) The strain in any fiber is directly proportionate to the distance of that fiber from the neutral axis.

(c) The modulus of elasticity of the concrete remains constant within the limits of the working stresses fixed in these Regulations.

From these assumptions it follows that the stress in any fiber is directly proportionate to the distance of that fiber from the neutral axis.

The tensile strength of the concrete shall not be considered.

15. When the shearing stresses developed in any part of a concrete-steel construction exceed the safe working strength of concrete, as fixed in these Regulations, a sufficient amount of steel shall be introduced in such a position that the deficiency in the resistance to shear is overcome.

16. When the safe limit of adhesion between the concrete and steel is exceeded, some provision must be made for transmitting the strength of the steel to the concrete.

17. Concrete-steel may be used for columns in which the ratio of length to least side or diameter does not exceed twelve. The reinforcing rods must be tied together at intervals of not more than the least side or diameter of the column.

18. The contractor must be prepared to make load tests on any portion of a concrete-steel construction, within a reasonable time after erection, as often as may be required by the Superintendent of Buildings. The tests must show that the construction will sustain a load of three times that for which it is designed without any sign of failure.

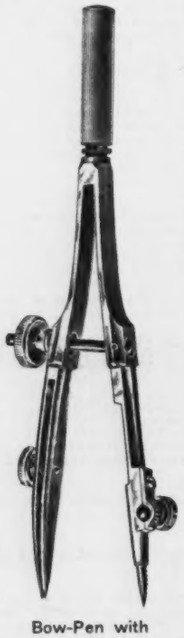
TWO LABOR-SAVING TOOLS FOR THE DRAFTING ROOM.

In the average manufacturing establishment, about the last place for labor-saving tools to find a foothold is the drafting room. This is partly due to the employers and partly to the draftsmen themselves. The bright men among the latter are so much interested in labor-saving tools and methods for carrying out the work under their charge that they have hardly paused to consider the need of saving their own labor or providing tools to enable them to do more rapid work. The plodders are perfectly content to plod along in the old way. They are paid by the time spent and they adopt the current fallacy that labor-saving tools means fewer men employed and lower wages.

Within the past dozen years, however, there has been a great change for the better in drafting-room methods, and there are now many progressive firms which are as ready to adopt lavor-saving methods in the drafting room as in any other department.

We illustrate herewith two ingenious little instruments, which will certainly commend themselves to every draftsman. The first is an automatic dotting pen. The pen itself is mounted on a vertical slide and is held in contact with the paper by a light spring. As the instrument is moved along, the serrated wheel beside the pen point is rotated by contact with the paper and drives the shaft above it. Upon this shaft is a series of five wheels with their rims cut in different ways, corresponding to different styles of dotted or broken line. An arm from the pen slide in contact with one of these wheels moves the pen up from the paper according to the projections on the wheel. The thumb screw at the left permits the user in a moment to change from one wheel to another to alter the form of dotted line desired. Dotting pens have been for some time on the market in which a single escapement wheel moves the pen up or down; but to change the form of dot necessitated taking off the wheel and substituting another.

An Automatic Dotting Pen.



Bow-Pen with Adjustable Needle Point.

In the present instrument, the draftsman has five standard forms of broken line available for use in a single instrument, and can change from one to the other as quickly as he could adjust a pen for thickness of line. The wheels can be made to order to give any desired standard form of dotted or broken line, and by their use uniformity in such lines is assured.

Tests of the instrument in the drafting room of Engineering News have shown that it does neat and rapid work; a dotted line is ruled with it as quickly as a straight line, and with perfect regularity and freedom from blotting.

The cut of the second instrument makes its construction clear. It is a needle-point for bow pens, adjustable by a rack movement, so that the point can be moved in or out to suit the opening of the dividers, the wear of the pencil point, etc. It is a simple little saver of minutes, but it is just such saving of seemingly small losses in time that in the end effect large economies.

Both these devices are the invention of Mr. E. G. Ruehle, of 41 West 24th St., New York city, and are being put on the market by him.

UNPRECEDENTED SPEED was reached on the Berlin-Zossen line, near Berlin, Germany, on Oct. 6, in the course of the experimental work of the "Studien-gesellschaft für elektrische Schnellbahnen." On the date mentioned, a maximum speed of 125½ miles per hour was reached. This line, it will be remembered, is a state military railway, less than 15 miles long, which has been loaned by the German government for the experiments of a society formed of electrical manufacturers and others, whose object it is to develop the principles of very high speed operation of electric railways. As constructed, the line employs three-phase current at a pressure exceeding 10,000 volts, taken to the car by bow-trolleys. The experiments began nearly two years ago; it was soon found that the track-work was far too light to permit of any record-breaking, and the runs were stopped after a maximum speed of about 95 miles per hour had been reached. Since then, the track has been reconstructed and new cars built. The runs were resumed during the present summer.

THE LORAIN SURFACE CONTACT RAILWAY line in Wolverhampton, England, was rejected by the town authorities after a year's trial, as noted in our issue of June 18, 1903, following a report on the system by the electrical engineer for the borough, whose conclusions were briefly noted in our issue of May 7, 1903. The Wolverhampton Council has now reconsidered its former action, and has voted to accept the existing line (11 miles) for the price of £22,000. Moreover, the Council also voted to enter into arrangements with the Lorain Steel Co. for equipping certain other street railway lines with the same system.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between a passenger train and a freight on the St. Louis & San Francisco Ry. near West Plains, Mo., on Oct. 1. Three men were killed in the wreck.

ELECTRIC RAILWAY ACCIDENTS in Chicago during September numbered 126, and 144 persons were injured in these accidents, according to the police records. During that month 35 persons were killed by being run over on the steam railways within the city, 14 were killed by the electric cars and one was killed by a cable car. The police records do not show the number of persons injured on the steam railways. The worst accident of the month occurred at 6.30 p. m. on Sept. 30, when an electric car crowded with people returning from the Harlem race track was struck by a Wisconsin Central Ry. train at the 52d St. grade crossing of the Illinois Central R. R. (over which the Wisconsin Central Ry. enters Chicago). The car was running at high speed, and did not slow up for the crossing nor did the conductor go ahead to look out for trains. Six persons were killed and eleven injured. On the same day an electric car was derailed while passing off the Lake St. bridge, owing to the bridge tender starting to open the bridge before the car was clear of the structure. The car was partially crushed by one of the trusses before the bridge was stopped, but nobody was injured.

THE FALL OF A BUILDING DURING ERECTION killed one laborer at Chicago on Sept. 24. The Western Electric Co. is having a large machine shop built at 48th Ave. and W. 22d St.; the building is of regular steel column and truss construction. According to the Chicago "Record-Herald," eye-witnesses report that

> the break-up commenced near the center of the 840-ft. structure, ran east and west almost simultaneously, and was all over within four seconds . . . Of the 26 trusses which at a height of 80 ft. spanned the 75-ft. gap between the upright columns, not one remained in position. Ten of the columns at the southeast corner of the structure also went crashing to the earth.

The cause of the accident is being investigated. The contractors who were erecting the steel-work are the Wm. Grace Co., and R. M. & E. C. Shankland were the engineers.

THE USE OF OIL FOR LOCOMOTIVE-FUEL on the Southern Pacific Ry. is to be extended, according to recent reports. A large number of engines on that line are already using oil as fuel, and it is now reported that the remaining engines are to be converted from coal to oil burning as rapidly as practicable.

A TEST OF NAVAL BOILERS is to be made on the U. S. battleship "Maine" during a test run from Norfolk Navy Yard to Porto Rico and return. The "Maine" is fitted with Niclausse boilers, and the test trip is for the purpose of comparing their work with that of other boilers in use in the U. S. navy. The commission which is to conduct the tests is composed of Capt. J. A. H. Smith, Commander W. B. Bailey and Lt.-Commander Parks.

STEAM TURBINES have been ordered for the power house which is to supply electric current for operating traffic through the Pennsylvania R. R. tunnel through New York city. Three turbines of about 7,400 HP. each have been ordered of the Westinghouse Machine Co., Pittsburg, Pa. They will be of the Westinghouse-Parsons horizontal, short-barreled type, and will drive three-phase generators of 5,500-KW. capacity each, direct connected to the turbine through a flexible coupling. Steam will be supplied at 200 lbs. pressure, superheated to 175° F.; a condenser vacuum of 28 ins. is to be maintained. The turbines will each have a by-pass, controlled by the governor, for taking up any sudden drop in load; the overload capacity will be 8,250 KW., or about 11,000 HP. It is intended that the three generators shall be operated in parallel.

It is reported that a new Cunard liner soon to be built will probably be fitted with steam turbines. The vessel in question will be 785 ft. long, and will have a displacement of 37,500 tons.

AN ELECTRIC HYDRAULIC POWER PLANT is to be established on the Chattahoochee River, about four miles west of Buford, Ga., by the Winding Shoals Electric Power Co., of Buford. The location selected for the dam and power house is an advantageous one, lying between high bluffs, which are composed almost entirely of solid granite. The plans contemplate the construction of a crib dam for which material can be secured in close proximity to the plant. The power house will be of stone and concrete construction. Details of the power-house machinery equipment have not been fully worked out, but the first equipment of wheels and generators will be for about 3,000 HP., which will ultimately be increased to 6,000 HP. A portion of the power will be utilized by local factories in Buford, which is the largest leather manufacturing district in the South, and for the Atlanta, Buford & Gainesville Ry., for which a survey is now being made. The balance of the power will be transmitted to Atlanta and surrounding towns; the bulk of it will likely be taken to Atlanta, Ga. The Electrical Equipment Co., Monadnock Building, Chicago, Ill., of which Mr. J. W. Peterson is president, is preparing the plans and specifications and will soon be ready to receive bids for the machinery equipment and construction work.

THE BOILER DESIGN COMMITTEE of the American Railway Master Mechanics' Association is issuing a circular asking responses to the following questions:

1. What minimum depth of water over highest point of crown sheet do you use or recommend (a) for curved crown sheets, (b) for flat crown sheets?
2. The distance from vertical line of boiler to water glass (a) for curved crown sheets, (b) for flat crown sheets?
3. What exposed length of water glass do you use or recommend?
4. How are gage cocks located with reference to water glass?
5. If crown sheets are sloped, how much per foot, and why?
6. Is an automatic low-water detector a desirable attachment for general use on locomotives? By an "automatic low-water detector" is meant a device giving warning when water is below safe level.

Replies should be sent to D. Van Alstyne, Superintendent Motive Power, Chicago Great Western Ry., St. Paul, Minn.

CREOSOTED TIES are but little used in this country, on account of the expense of this system of treatment, due to the limited supply and high cost of proper creosote oil. The report of the tie committee of the American Railway Engineering and Maintenance of Way Association shows, among other things, that the New York Central Ry. has 18,700 creosoted ties, while the New Orleans & Northeastern has 30,206 creosoted ties. Those of the former contain 10 lbs. of creosote per cu. ft. and cost $1.35; those of the latter railway contain 13½ lbs. per cu. ft. and cost $1.26 (the untreated ties costing 36 cts.). On the other hand, the Southern Pacific Ry. alone has, on its Pacific system, 5,027,775 ties treated with chloride of zinc, and having 0.243 lb. of pure zinc chloride per cu. ft. of tie. The first cost of these ties was 27 cts.; extra handling and transportation, 1 ct.; preservative treatment, 10 cts.; making a total of 38 cts. per treated tie.